FORECASTER'S HANDBOOK

COMMANDING OFFICER

Marine Corps Air Station
Yuma, Arizona 85369-9160

FORECASTER'S HANDBOOK

JANUARY 1999

LOCAL AREA FORECASTER'S HANDBOOK

5 JANUARY 1999

FOREWORD

This publication was prepared in accordance with NAVOCEANCOM instruction 3140.2_ and is a revision of the April 1996 edition.

The specified purpose of the Forecaster's Handbook is to provide newly assigned Weather Forecasters with guidelines on local area weather associated with typical synoptic scale developments. The handbook also serves as a ready reference and review for seasoned forecasters in the Yuma area.This handbook is not the work of any one individual, but rather a compilation of many past and present Yuma forecasters. Their contributions are greatly appreciated.

All recommendations concerning changes, additions, or deletions to improve the effectiveness of this handbook are encouraged. Additional copies may be obtained by contacting this office.

J. A. SMITH
WEATHER OFFICER

DISTRIBUTION

COMNAVMETOCCOM, STENNIS SPACE CENTER, MS
NAVENVPREDRSCHFAC
NAVPGSCOL (CODE 63 MET LAB)
CO NAVMETOCOFF, USAF E TAC/C8E, SCOTT AFB, IL 62225
NAVPACMETOCCEN, PEARL HARBOR, HI
NAVPACMETOCFAC, SAN DIEGO, CA
CMC (ASL-44)
MARCORDET, KEESLER AFB, BILOXI, MS
V4 MARCOR AIR FACILITY (ATTN: WEATHER SERVICE OFFICER)
V5 MARCOR AIR STATION (ATTN: WEATHER SERVICE OFFICER)

RECORD OF CHANGES

CHANGE NUMBER	CHANGE DATE	DATE ENTERED	ENTERED BY

TABLE OF CONTENTS

LIST OF FIGURES

APPENDIX

SECTION I

BASIC DESCRIPTION

1. STATION DESCRIPTION

a. Location Marine Corps Air Station Yuma, Arizona, (69960.4) is located at 32^{o} 39' N 114^{o} 37' W in theYuma Valley. The city of Yuma borders the air station to the northwest. Yuma International Airport and MCAS are a joint facility. Light civil aircraft primarily use the short runways, 08/26 and 17/35. The long runways 03/21 right and left are primarily used by military and large civil aircraft.

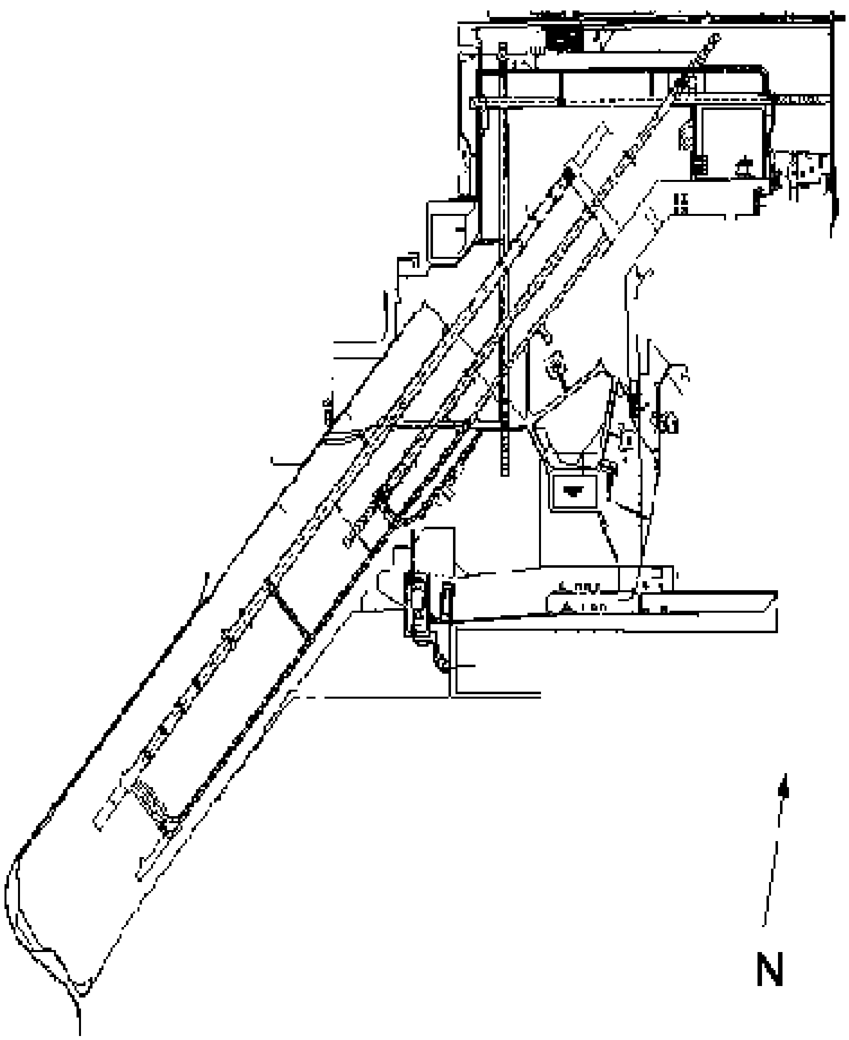


Figure 1-1

b. Local Topography The Yuma Valley, is for the most part, a flat desert region with elevations generally less than 500 feet MSL. Much of the desert has been reclaimed for farming. Because of this, extensive irrigation canals cover the area providing water for citrus, cotton, and vegetable crops. The valley is surrounded by mountains except 50 miles to the south where it reaches the Gulf of California. The Gila Mountains, 13 miles east, are the closest mountains to the air station. The sand dunes are 8 miles west of Yuma in the Imperial Valley. They extend to the northwest for a distance of 47 miles. This area of fine sand has an average width of 6 miles except for the last few miles where they taper down to a 2 mile width.

c. Facilities The Weather Service Office at MCAS Yuma occupies some 982 square feet in the south corner of building #153. The north end of building #153 is used as a snack bar and Navy PSD. The Weather Service, Flight Clearance, and Airfield Operation departments share the south end of the building.

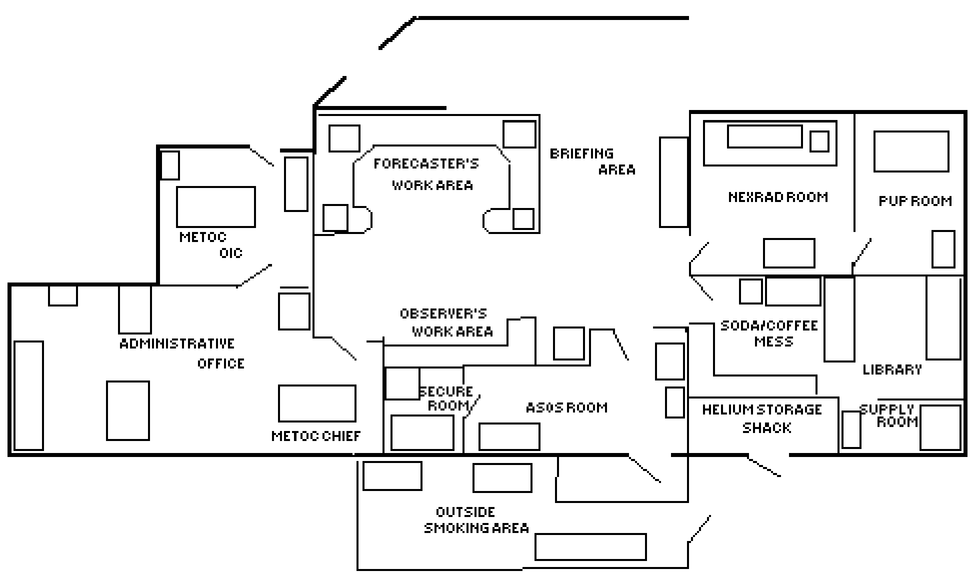


Figure 1-2

d. Local Area The Local Area covers a radius of 25 miles from the operations building.

e. Local Flying Area The MCAS YUMA local flying area is defined as that area bound by a line as follows: from MCAS Yuma, westward along the U.S. border to the Pacific coast, northwest along the California coastline to San Luis Obispo Vortac, northeast to NAS Lemoore, direct to Coaldale Vortac, east to Milford Vortac, direct to Zuni Vortac, south to the U.S. border, then westward along the U.S. border to MCAS Yuma.

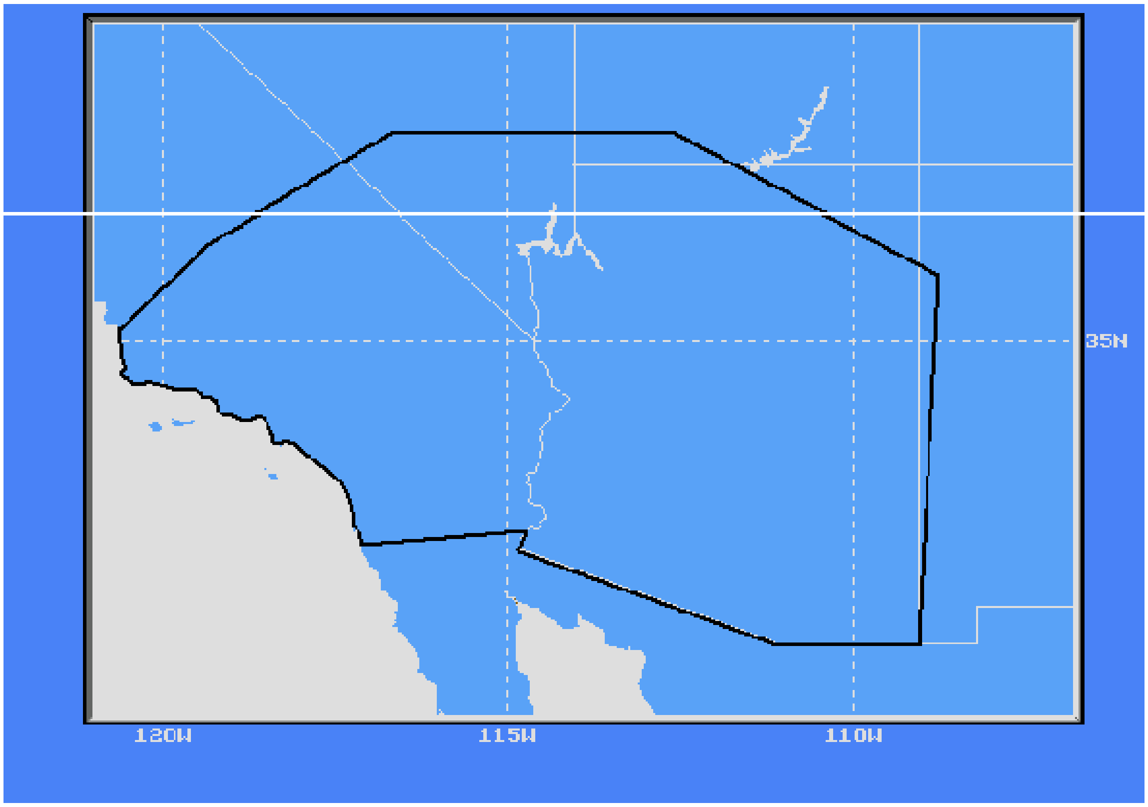


Figure 1-3

f. Local Ranges MCAS Yuma provides support to aviators using all the local gunnery ranges. Flight briefings for aircraft using the targets/ranges will be a large portion of the Yuma forecasters duties.

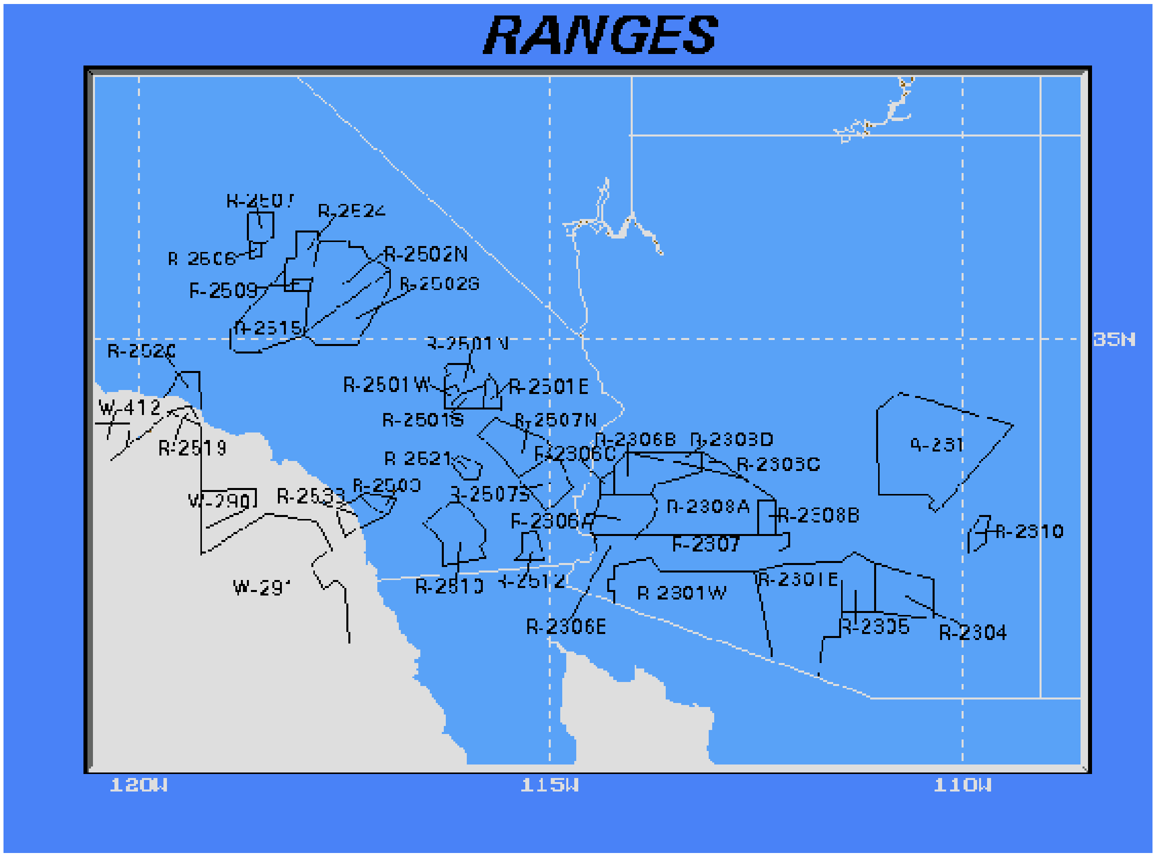


Figure 1-4

2. <u>COMMAND AND STAFF SUPPORT REQUIREMENTS</u> In addition to the usual requirements of a weather service, Yuma Weather Service is tasked with providing support to three tenant units, a large number of deployed detachments for training, Laguna AAF at Yuma Proving Ground, NAF El Centro, CA, the Aerostat site, and numerous transient aircraft.

a. <u>Marine Aircraft Group 13</u> (MAG 13), consists of three flying squadrons. VMA-214, VMA-311, and VMA-513 all flying the AV8B Harrirer. VMFT-401, 4th Marine Air Wing, is the aggressor squadron and fly the F5 Tiger. The support to these squadrons consists primarily of flight briefs to the local training area, an occasional cross country flight requiring a HWD package, and an infrequent TRANSPAC brief. MAG-13 is a command under the Third Marine Aircraft Wing at MCAS Miramar, CA.

b. <u>Marine Air Control Squadron 1</u> (MACS 1) Marine Air Control Group 38. MACS-1 support is in the form of climatology for deployment throughout the southwestern United States, approximately four per year.

c. <u>Laguna AAF, Yuma Proving Ground (YPG)</u> MCAS Yuma Weather Service handles all aviation flight briefings for Laguna. This is usually 10 to 20 phone or fax briefs per month and a semi-annual safety stand down weather brief. From them, we are provided a copy of their 1200Z upper air sounding Monday through Thursday.

d. NAF El Centro, CA Limited weather support is available at NAF El Centro. Aircrews are directed to call MCAS Miramar, CA for support. On those occasions when Miramar is busy, most air crews call MCAS Yuma for a phone brief.

e. Deployed Units MCAS Yuma hosts 120 to 130 deployed units, predominately Marine Corps and Navy, a year for training on the local ranges. The detachments fly some 14,000 sorties, and account for a large majority of our weather briefs.

f. Transient Aircraft Due to good weather, availability of fuel and location, MCAS Yuma is a popular intermediate stop on cross country flights. Approximately 7,500 aircraft stop at MCAS Yuma each year. Many of these require weather updates for their final destination.

g. Station Support Support for the air station itself consists of providing weather briefs for five aircraft, two C-12's and three UH-1 SAR aircraft. The Weather Service also issues Local Weather Advisories/Warnings, conducts climatological studies/briefs, computes the WBGT index, and disseminates the daily forecast.

h. Marine Aviation Weapons and Tactics Squadron 1 (MAWTS-1) MAWTS-1 is a weapons training squadron , conducting classes in February and October for six weeks. Support is in the form of weather briefs for the local training areas, specialized forecasts (stand up briefs for WTI students), and departure briefs.

i. Aerostat Site The Aerostat site is approximately 30 miles northeast of MCAS Yuma. This site controls a search radar mounted beneath an aerostat, tethered by a cable, and then raised to a height usually from 12,000 to 14,000 feet. Their primary concern is low and mid level ceilings, thunderstorms, turbulence, and wind speeds and direction below 15,000 feet. This radar is responsible for monitoring the Southwestern U.S.. Weather support consists of daily forecasts every day of the week plus warnings and advisories.

j. Summary of Support MCAS Yuma Weather Service annually performs approximately 7,500 DD 175-1 briefs, issues about 300 weather advisories/warnings, conducts 25 to 35 TRANSPAC/cross country briefs and fulfills OPARS requests when needed.

3. WEATHER EQUIPMENT AND LOCATION

a. Automated Surface Observing System (ASOS) The ASOS performs all the basic observing functions such as acquisition, processing, distribution, and documentation of data. The sensors for the ASOS are located 4,380 feet from the north end of runway 21L and 880 feet east of the centerline.

b. Weather Surveillance Radar (WSR-88D) KYUX

1) The WSR-88D (commonly referred to as NEXRAD) is a Doppler theory based system. The system completes an environmental scan every ten minutes (approximately), and provides products from the three base data fields of Reflectivity, Velocity, and Spectrum Width.

2) The WSR-88D is composed of three main components:

a) Radar Data Acquisition (RDA) unit, located 10 miles south of MCAS Yuma

b) Radar Product Generator (RPG), located in the National Weather Service office in Phoenix, Az.

c) Principle User Processor (PUP), located in room 104 of the Weather Office

c. METOC Integrated Data Display System (MIDDS)

1) The MIDDS is a four part system, the Forecaster's briefing station, which contains a dual Pentium server, the Forecaster's workstation, the Observer's workstation, and the Wall of Thunder. The system is located in the main office briefing area. This system has internet service and serves as a Weather homepage for access to weather data. The MIDDS subsystems are as follows:

a) Facsimile (DIFAX):

1. CNOC provides facsimile service at Yuma. All data is transmitted from the National Weather Service in Suitland, MD, via leased phone lines from AT&T to DMC, Mountain View, CA where it is transmitted via satellite to all users.

2. In case of signal malfunction, the procedure to follow and numbers to call may be found in the equipment outage log.

b) NODDS/OPARS: These systems use the direct dial out service of the MIDDS external modem through both the server and the workstations. The primary access service is the NIPRNET with Sprint serving as a commercial backup.

d) GVAR: This is the method for receiving GOES satellite imagery. It is ingested in the MIDDS via the direct dialer RX monitor. This data originates at NAS North Island. The point of contact for any problems is the MIDDS help desk.

e) The Weather division also maintains a web page at the following address: http://205.109.165.245. This site depicts local and national weather. The homepage will be updated daily prior to the morning watch relief. The homepage will be backed up weekly.

d. Thermoscreen (ML-42) The thermoscreen is located 130 feet east of building #153. It contains an electric and sling psychrometer. These instruments are used as a back-up for the ASOS. Readings taken from these instruments may differ slightly from the ASOS.

e. Rain Gauges The four inch plastic rain gauge (ML 217) is the primary back-up precipitation measuring instrument. This gauge is mounted on a 3 foot post 12 feet west of the thermoscreen. The 8 inch aluminum rain gauge is used as back up. The 8 inch rain gauge, belonging to the National Weather Service, is the secondary back-up and is mounted on a concrete block 12 feet south of the thermoscreen.

f. Aneroid Barometer (ML-448) Mounted on the south wall of the observer's work area, building #153, and is 213 feet above MSL.

g. WBGT The primary WBGT setup is located 10 feet south of the thermosceen. A secondary setup is located 50 feet north of the thermoscreen.

h. Theodolite The primary theodolite position for PIBALS is located on top of the observation platform. The secondary position is located next to the thermoscreen.

i. Weather Vision Weather vision is accomplished using a PC located in the Weather office that is connected to the Instructional Television Network (ITV). During working hours this system is used for training. After normal working hours, the system is connected to the local area cable TV service (Yuma Cable Vision). Weather data is transmitted over this system 24 hours a days.

j. Aerovane The wind detector is located 4,380 feet from the north end of runway 21 and 880 feet east of the centerline. It is 16 feet above the ground level and 203 feet above MSL. There is an ID586 indicators on the north wall of the Weather Office, tower and RATCF. Since this instrument is located more than two miles from the touchdown point of runway 03L, the winds may not always be representative.

k. Ceiling Light (WB 804) Similar to the ML 121, it is located on top of building #401. There are two established baselines: One is 507 feet with the benchmark located outside the ASOS room door. The other is 475 feet with the benchmark located adjacent to the thermoscreen. The timer switch is located on the north wall of the Weather Office under the ID586 wind indicator.

l. Meteorological Oceanographic Support System (MOSS) This system is used for EOTDA and GFMPL and is located in room #102 of the Weather Office.

4. WEATHER COMMUNICATIONS

a. Tower/RATCF Phone A direct line phone is located on the wall next to the Aneroid Barometer in the Weather office. This is connected to the tower and Radar Air Traffic Control Facility (RATCF). This phone is used for rapid dissemination of data between sections.

b. Telephone Facsimile A telefax machine is located on the flight briefing counter. The fax number is DSN 951-2250 or commercial (520) 341-2250. The telefax is used by Weather and Airfield Operations for filing Flight Weather Briefings, transmitting daily forecasts, flight schedules, NOTAMS, and correspondence requiring immediate attention.

c. Pilot to Forecaster Service (METRO) The remote box is located in the Weather office. The radio is a TTC-8/800FRC with transmitter receiver located in building #1520. The frequency is 349.9 mhz.

SECTION II

CLIMATOLOGY

NARRATIVE CLIMATOLOGICAL SUMMARY

The climate of Yuma is definitely a desert product. During the winter, November through March, the skies are abundant with sunshine. Frost is not uncommon in the valleys and is expected on higher elevations. The sun does not shine all of every day, but comes nearer to doing so at Yuma than at any other place in the United States for which records have been kept. In December and January, the lower Colorado River Valley averages better than eight hours of sunshine a day. Afternoon temperatures reach 100^{o}F from June through September, and at least 105^{o}F during July and August. The transitional periods, spring and fall, usually occur during March-April and October-November, and are short lived usually two weeks or less.

ANNUAL CLIMATIC CONDITIONS

TEMPERATURE	
AVERAGE MAX	88^{o}F
AVERAGE MIN	60^{o}F
ABSOLUTE MAX	124^{o}F
ABSOLUTE MIN	24^{o}F
AVERAGE	74^{o}F

HUMIDITY	
0500L	49%
1400L	22%
1700L	21%
AVG	35%

PRECIPITATION	
ABSOLUTE MAX	6.9 ins
ABSOLUTE MIN	0.3 ins
AVERAGE	3.5 ins

SKY CONDITION	
CLEAR	55%
SCT	22%
BKN	14%
OVC	9%

FIELD CONDITION	
IFR	1.0%
VFR	99.0%

THUNDERSTORM	
AVG # OF DAYS	2.1

SURFACE WINDS	
ALL HOURS	N 8.0 kts
MAX	SE 66.0 kts

CEILING/VSBY	
<3,000 & 3 mi	1.0%
<1,500 & 3 mi	*
<1,000 & 3 mi	*

* < than 0.5%

1. Temperature MCAS Yuma's mean annual temperature is 74^{o}F with a daily average maximum of 88^{o}F and a daily average minimum of 60^{o}F. The absolute maximum temperature for the station is 124^{o}F, occurring on 28 July 1995, and the coldest day of 24^{o}F on 8 January 1971. Climotologically, January is the coldest month of the year and July the hottest.

2. Precipitation With MCAS Yuma located in the low desert region, precipitation is minimal. The annual average rainfall is 3.50 inches. Historically, December and August are the wettest months with a mean rainfall of .62 and .72 inches, respectively. The wettest year on record, occurred in 1905 with 11.41 inches and the driest in 1956 with .30 inch. Snowfall at MCAS Yuma was recorded in December of 1932 with 1.5 inches. A trace fell in January 1937, and December 1967.

3. Wind There is a marked shift in the seasonal prevailing wind direction from a northerly component in the winter to a southerly component in the summer. This 180^{o} difference is the result of the Great Basin High to the north-northwest and the Thermal Low over or north of Yuma with higher pressure to the south in the summer. The orientation of the Colorado River Valley also serves to enhance the north/south wind direction. The average velocity throughout the year is 8 knots. The highest wind speed ever recorded was 66 knots. This occurred during September 1976.

4. Field Conditions VFR field conditions exist at MCAS Yuma in excess of 99% of the time with visibility being greater than 7 miles more than 98% of the time. The ceilings over Yuma are greater than 10,000 feet 87% of the time, and clear skies occur 48% of the time. Blowing dust, sand, and infrequent periods of fog, are the main causes of IFR weather at Yuma.

5. Pressure A monthly composite of mean pressure is available. Diurnal pressure graphs are located in the appendix portion of this handbook. These graphs are an invaluable aid in altimeter forecasting.

6. Monthly Summary

a. January

The Jet Stream and associated storm tracks have migrated to their southern most position. This gives Yuma a generally stronger westerly flow aloft compared to the rest of the year. The majority of fronts affecting the local area move through at a faster speed than other months. This results in less accumulation of precipitation than December. January is the coldest month of the year, yet, it is considerably milder than other areas of the country at the same latitude.

b. Febuary

The Jet Stream and its associated storm tracks have started their northward migration for the upcoming summer. This migration begins to weaken the high pressure system that has dominated the northwest since autumn. This weakened state allows the Nevada Low pressure system to affect the local area.

c. March

The Pacific Ridge begins to migrate north and gradually intensify. The Thermal Low Trough begins to establish in New Mexico, Arizona, and southeastern California. With the influx of warmer air, the high pressure located over the northwest U.S. has almost disappeared. This weakened state allows for more frequent affects of the Nevada Low pressure systems.

d. April

Mid-April through mid-October is Yuma's summer season. The Subtropical Ridge continues its northward migration and intensifies. The Nevada Low is almost nonexistent during this month. These situations normally result in no thunderstorms and no precipitation.

e. May

The Jet Stream and associated storm tracks have migrated too far north to affect the local area. The upper level flow is predominantly from the west and dry. These combined features result in the "Dry Monsoon", high temperatures and low humidity.

f. June

The Dry Monsoon has its strongest affect on the local area during this month. Moisture is usually blocked by the mountains located west of Yuma. This lack of moisture results in rare occurrences of thunderstorms. If thunderstorms do occur, ceilings are fairly high due to the lack of low level moisture.

g. July

The Bermuda High has migrated to its northern most position. The flow aloft has become more southerly to southeasterly advecting moisture from the Gulf of Mexico and the Gulf of California into Arizona. This moisture, along with higher temperatures, increase the possibility of thunderstorm activity over Yuma.

h. August

The position of the Bermuda High has not changed from July, but now covers a more extensive area. The easterly flow from the high is at its greatest, bringing moisture in as far as northern Arizona and southeastern Nevada. The Thermal Trough also covers a more extensive area influencing regions as far north as Oregon. This results in the highest number of thunderstorms and the wettest month of the summer season.

i. September

The Bermuda High begins to weaken and cover a smaller area. The Thermal Trough is now at its most intensive stage. The majority of thunderstorms occurring usually affect the mountains east of Yuma. Due to upper level winds, the potential for tropical cyclones affecting the local area is at its greatest.

j. <u>October</u>

The Thermal Trough has started to weaken and its area of influence is gradually receding southward. The Pacific High has also started its southerly migration. A weak area of high pressure sets up over the northwestern U.S.. Fronts occasionally affect the local area with little cloud coverage or precipitation. After frontal passage, strong northwesterly winds occur in the local area.

k. <u>November</u>

November begins our winter season. High pressure systems (Great Basin High) begins to set up over the northwest. The Thermal Trough extends over southeastern Arizona, which is considerably weaker than October. This results in mild temperatures, breezy wind and little precipitation for the area.

l. <u>December</u>

With the southward migration of the Jet Stream and its associated storm track, a Cut-Off Low may develop off the coast of southern California. This period of transition causes a significant change in the temperature and precipitation, along with a noticeable difference in humidity. The greatest chance of fog (after frontal passage) occurs during this month.

SECTION III
<u>FORECASTING</u>

1. Seasonal Weather There are basically two seasons for the Yuma area: summer and winter. Normally, there is little more than a week or two of rapid transition to the dominant seasons of summer and winter. Spring and autumn show few, if any, of the seasonal characteristics normal to other parts of the United States.

a. Summer Mid-April through mid-October comprises the summer season. The first portion of summer is dominated by both low and upper level flow. Even though the source of this air is the eastern Pacific ocean, the air is very dry because the moisture is trapped in the shallow marine layer on the windward side of the coastal mountain ranges. By mid-July, the flow becomes more southerly bringing moisture from the Gulf of Mexico and the Gulf of California into the Yuma area. This results in increased rainshowers and thunderstorm activity causing August to be one of the wettest months of the year.

b. Winter November through March comprises the winter season. Weather during this season is characterized by long periods of excellent flying weather, occasionally interrupted by active cold fronts, cutoff lows and upper level troughs.

2. Special Features

a. Thermal Low/Trough This semi-permanent feature is often referred to as an inverted trough or heat low. The trough is formed by the intense daily heating of the desert area of southern California, western Arizona, and northwestern Mexico. While the position of the trough is affected by large scale synoptic patterns, its position also varies seasonally. In the winter the lowest pressure is over northwestern Mexico, with the trough extending north into the Imperial Valley/Mojave Desert/Las Vegas region. As depicted in figure 3-1, the trough may extend as far north as Oregon in the summer.

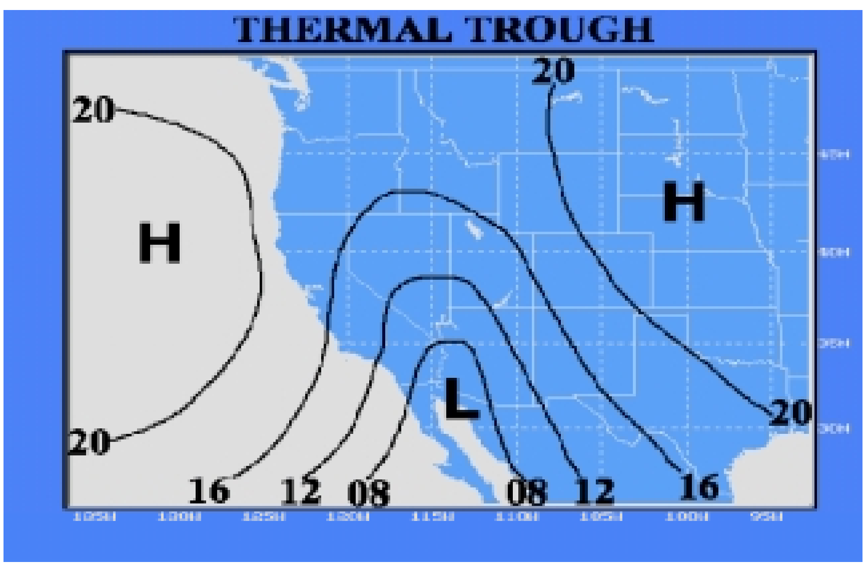


Figure 3-1

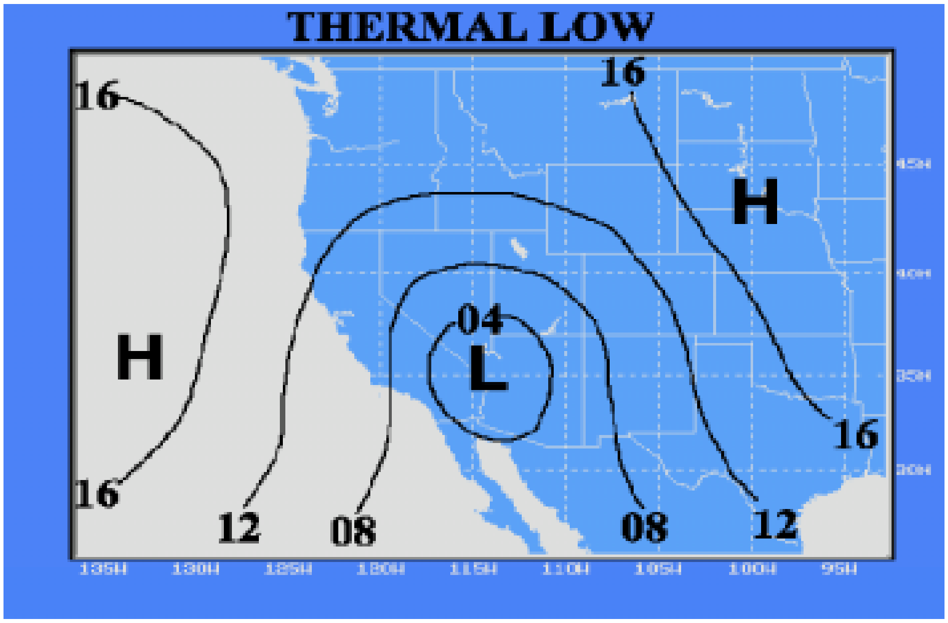


Figure 3-2

1) In the summer, the Thermal Low poses a peculiar forecasting problem at Yuma. The direction of the surface wind depends entirely on the location of the low center. Once the low pressure center is located, the wind direction will be nearly parallel to the isobars. In figure 3-2, the wind direction would be from the west. Wind speed associated with the thermal low range from light and variable with a weak low, to 10 to 16 knots with a well developed low, averaging 7 to 10 knots in most cases. Surface wind directions associated with the Thermal Trough are also highly variable and extremely difficult to forecast, since the trough axis often fluctuates back and forth over the Yuma area in the course of the day.

b. <u>Wet Monsoon</u> Each year, a portion of the summer months in Arizona are devoted to hot and humid weather, popularly referred to as the "Wet Monsoon". This condition normally commences in early July and persists, with occasional breaks, until September. The monsoon is characterized by surges of maritime tropical air. Combined with strong solar insulation, it produces uncomfortable heat and humidity. During this period, dry continental air is replaced by very moist tropical air. The moisture source of this tropical air is believed to originate from two locations; the Gulf of Mexico and the Gulf of California. For a detailed study on the subject, see the reference material as listed at the conclusion of this publication.

1) <u>Sonora</u> The Sonora is a summertime thunderstorm situation that effects the mountains and lower desert regions of the southwestern United States (July, August, and September). The traditional source of moisture is the Gulf of Mexico. As the summer progresses the Bermuda High builds north and west. This strengthens the easterly trade winds under the high and advects warm, moist, tropical air across northern Mexico into Arizona and southern California. With this pattern, ceilings will average 4,000 to 6,000 feet and moderate to heavy showers will occur. Thunderstorm activity will initially form in lines parallel to the mountain ranges. By mid to late evening the activity will migrate off the mountains with cells

normally following the mid-level winds (500 MB). The most hazardous threat to operations is the strong gusty winds that accompany these storms. To forecast the onset of this situation, the following key points should be observed:

a) Bermuda High center along the east coast of United States (North Carolina-South Carolina)

b) Strong easterly trades under the southern periphery of the Bermuda High. The stronger the flow, the more severe the thunderstorms will be

c) Proper analysis of satellite pictures prove to be an invaluable tool for short range forecasting

d) Higher than 70% relative humidity at 11Z

e) Stability Index of -1 or less

f) 500 MB dew point over southwest AZ -20^{o} or wetter (-10^{o} is great)

g) Southerly or southeasterly winds on the 12Z sonde

h) 500 MB flow perpendicular to -20^{o} dewpoint blowing dry to moist

2) Gulf Surge Sometimes incorrectly termed a nocturnal wind. It is a strong southerly wind that normally occurs between mid-July and mid-September. This wind is generated by thunderstorm activity over western Mexico. As the cool, dense air from this activity pushes northward into the dry, hot air over western Arizona, a strong pressure and temperature gradient is established. This gradient results in a strong wind or surge that normally begins during early morning hours (0400L-0600L), but have been known to occur at various times throughout the day. Due to the sparse data to the south, accurately forecasting the onset of a Gulf Surge is almost impossible. At present, continual monitoring of satellite data of the northward migration of thunderstorm activity over the gulf and the surface temperatures of the local area have proven the best tool. Thirty minutes prior to arrival, a sharp rise in pressure (.5 to .8 MB) will occur. With their arrival, surface winds will become southerly at 15 to 18 knots with gusts in the mid 30's. As the surge passes, the temperature usually decreases and the dewpoint increases. In most cases, the wind will diminish after four to six hours. This surge brings an intrusion of tropical maritime air into southwestern Arizona. If the depth of this moist air continues to increase to 700 MB, cumuliform clouds develop. This usually occurs one to two days after the surge. The tropical air usually persists for 6 to 10 days with numerous thunderstorms in the vicinity.

c. Tropical Storms Most tropical storms in the Eastern Pacific, develop in June through October with the greatest frequency occurring in August and September. The vast majority of tropical storms originate in the Gulf of Tehuantepec, the narrowest part of the Mexican Isthmus, and move west to northwest along the coast, past the tip of the Baja Peninsula and out into the open Pacific toward Hawaii. A few storms occasionally move northward along the Baja coast. They will usually dissipate as a result of the loss heat energy, due to cold sea surface temperatures, strong vertical wind shears, and friction from the mountains on both sides of the Gulf of California. When a tropical storm recurves and crosses the Baja Peninsula or western Mexico, it frequently results in impulses of tropical moisture in the local area. With tropical storm activity occurring in the Gulf of California or along the west coast of Baja, the forecaster should always be alert for the possibility of a storm moving into the local area. By the time it reaches Arizona, it is usually a weak low pressure system or a tropical depression due to the reasons explained above. However, the air mass is still warm and humid and may trigger rainfall of 3 to 4 inches as it moves across the desert valley. Appendix A contains a chronological summary of two of the few storms known to have significantly affected the local area.

d. Cutoff Low During the winter months, a long-wave trough, which is often slow moving or nearly stationary, will sometimes become situated just off the west coast. As a series of short-wave troughs traverse the area, new surges of cold air enter upstream of the long-wave. In the rear of the trough, an insulated pool of cold air causes a closed low aloft to form. As this closed low becomes displaced equatorward out of the westerly current, it becomes "cutoff". Once the isoheights and the isotherms become closed and nearly in phase, vorticity is no longer advected out of the low, and the low becomes stationary. Normally forming in 24 to 48 hours, these lows have a 24 hour to one week persistence range and a 72 hour to two week dissipation range. A well defined cutoff low will effect the Yuma weather when we fall under the cyclonic curvature around the low. When this occurs, multiple layers of clouds with ceilings below 2,000 feet and intermittent light to moderate rain may be expected. If the Cutoff Low sets up in the vicinity of 30°N (figure 3-3) and persists (stationary or drifting eastward), ceilings of less than 2,000 feet and continuous light to moderate rain is not uncommon. As the low persists and becomes more unstable, embedded thunderstorm activity increases. The thunderstorm activity is usually associated with minor troughs rotating through the system. If the Cutoff Low sets up north of 32°N (figure 3-4), the effect on Yuma is usually scattered to broken low and mid clouds and scattered rain shower activity, associated with vorticity lobes rotating around the low.

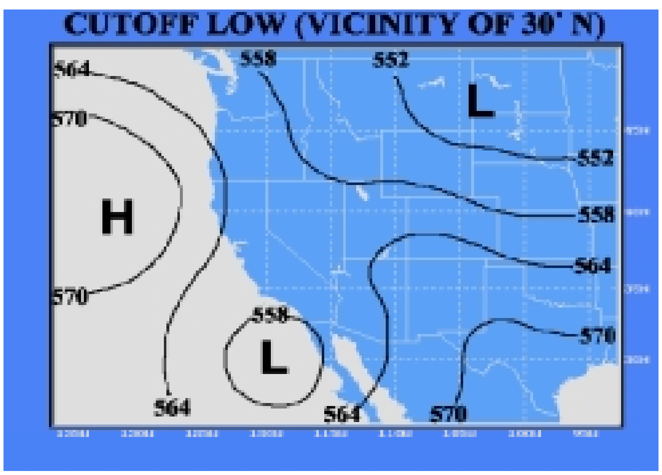


Figure 3-3

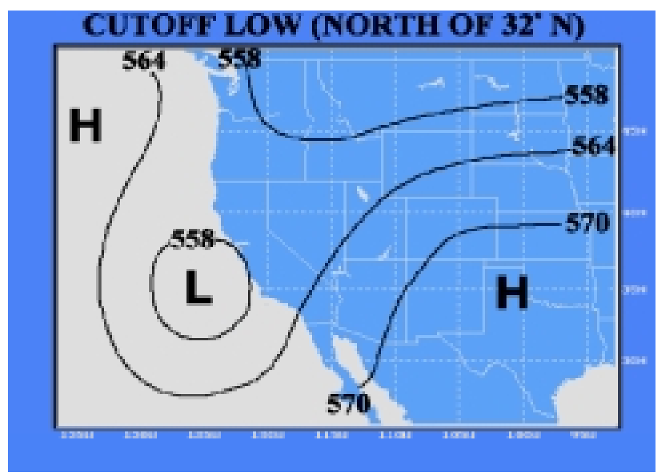


Figure 3-4

e. Nevada Low A "Nevada Low" is a local name given to the surface reflection of an upper level closed low or deep trough over Nevada. The Nevada Low is typically a "cold " low which develops during the February to April period, producing strong pressure gradients over western Arizona, Nevada, Utah, and southern California. The conditions for the formation of a Nevada Low are similar to the conditions for the development of a Cutoff Low. The low will normally develop in one of the following manners:

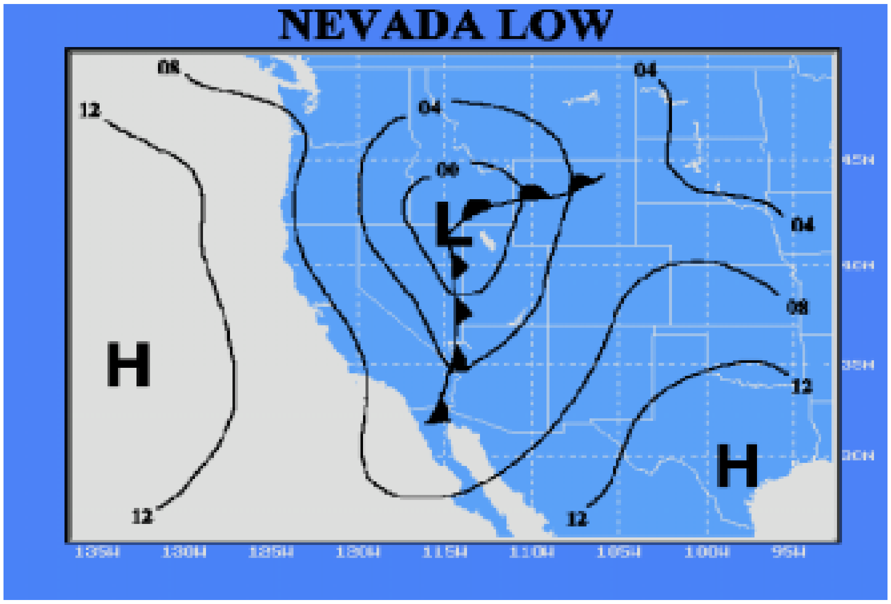


Figure 3-5

1) As a wave on an east-west oriented front.

2) As a secondary low in an unstable air mass following the passage of a frontal low.

3) Beneath a Cutoff Low, or at the tip of a deep trough which has a jet maximum moving into it. A well defined frontal zone is usually observed over southern California, Nevada, and the Utah Desert areas once the Nevada Low is well established. (figure 3-5) However, significant cloudiness and precipitation are not normally experienced at Yuma with the Nevada Low. Occasionally a minor trough or vorticity lobe moving around the low will pass over the local area producing middle and high clouds along with cumuliform buildups. The primary problem with a Nevada Low is the strong winds associated with the low. The best forecasting tool to determine wind speeds is a constant checking of gradient. With a well developed Nevada Low over southern Nevada, Yuma can expect southwesterly to northwesterly winds sustained at 15 to 20 knots with 30 to 40 knot gusts following frontal passage. Occasional IFR periods in blowing sand and dust may be expected under these conditions. With less intense systems, the wind may cross isobars at 90 degrees due to the Colorado River channeling effect. Wind in advance of the front will be southerly at 12 to 16 knots with gusts to 28 to 30 knots and no significant restriction to visibility.

f. <u>Great Basin High</u> The Great Basin High occurs when an intense high pressure system moves into the Nevada/Utah area (figure 3-6). For Yuma, the strong surface winds associated with this system normally commence right after cold frontal passage. The wind flow will be 90 degrees across the surface isobars and down the Colorado River Valley. If assisted by strong steering winds aloft (northerly 80 to 100 knot winds at 500 millibars), sharp surface pressure rises and a rapidly increasing surface pressure gradient will develop between Yuma and Las Vegas. This will result in a strong flow down the Colorado River Valley affecting Las Vegas, Needles, Blythe, and Yuma. Normally, the strongest winds at Yuma will be associated with the passage of the 600 mb trough.

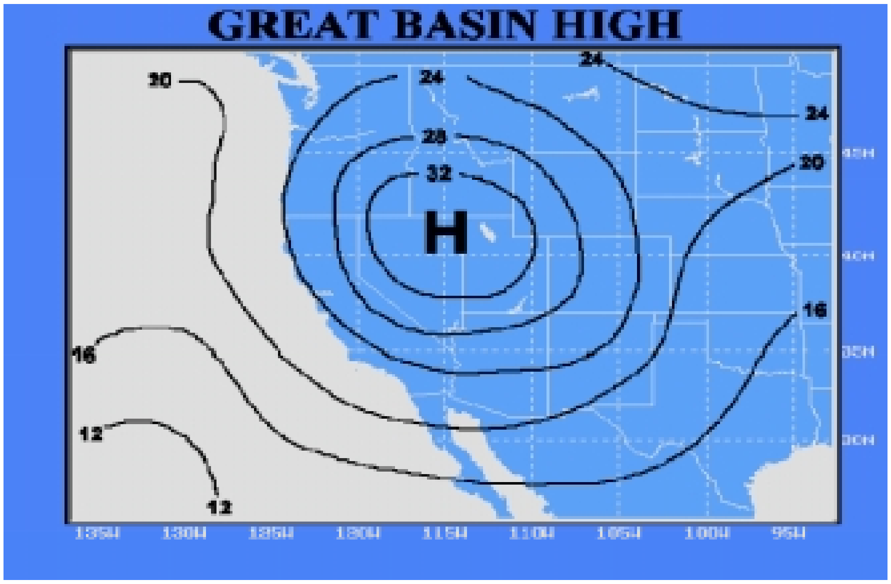


Figure 3-6

The winds with this high can last all day, diminishing around sunset with a moderate system and continuing beyond midnight with a strong system. The winds tend to re-develop the next day, though somewhat weaker. With the synoptic situation depicted in figure 3-6 and a considerable temperature difference (10°C or more) between LSV and NYL, the pressure gradient between LSV and NYL will result in the following winds:

4-6 MB - 10 to 20 G30

6-8 MB - 15 to 25 G35

8-10 MB - 20 to 30 G40

10+ MB - 25 to 35 G45 to 50

g. <u>Cold Trough with a surface low</u> This wintertime situation has high potential for producing precipitation and ceilings below 5,000 feet. As the cold trough moves into an area just west of the California coast and stagnates, deepening will occur. When this system is at or south of Yuma's latitude, precipitation is most probable. Usually, a surface low will be induced if one is not already present. Initially the eastward movement of the system is slow. The progging of the -25°C isotherm at the 500 MB level to the south of the station is an effective way to time the increases in instability. Increasing southerly winds at the lower levels transport additional moisture northward from the Gulf of California. This system develops at night and tends to dissipate during the late afternoon. Early indication of the strength of one of these systems, in addition to the isotherm pattern, is shown by strong gusty surface winds and heavy rainshowers in northern California. This spreads southward through California in the course of the 24 hours with the deepening of the trough and the southerly course of the surface low. Progging of the -25°C isotherm to the south of the station at 500 mb is an effective way to time the maximum intensity of the system at this station. It must be pointed out that this is not an annual occurrence. The cloud progression, with a strong system brings first cirrostratus, thickening and lowering to less than 20,000 feet. Approximately four hours later, ceilings will form below 10,000 feet and 5,000 feet in the course of another four hours. Ceilings as low 3,000 feet may develop at night and taper off in the morning. A moderate system of this type will produce multiple cloud layers with bases around 10,000 feet, accompanied by light rainshowers.

h. Fog The occurrence of fog at Yuma is rare. When it does occur, it is usually confined to the groves and the river area. However, there is one synoptic situation that is favorable for fog formation at the station; substantial rainfall of .10 inches or greater starting after sunset and lasting through the evening. Rapid clearing and light winds of 2-5 knots is an ideal set up for radiation fog formation resulting in IFR conditions. A temperature dewpoint spread as much as four degrees is not uncommon with totally obscured field conditions. This fog tends to burn off slowly with VFR conditions developing by late morning.

3. Thumb Rules MCAS Yuma is renowned for its desert climate. Most rules of thumb apply to summer situations. There are none that truly apply to the winter, but a few can be used year round. The following is a list of rules that apply to our seasonal patterns:

a. Broken cirrus will form when the dewpoint value at the 400 mb level is-30^{o} C or warmer.

b. A southeasterly and southwesterly converging flow over Yuma at 500 mb will produce layered clouds with bases at 10,000 feet and tops extending upwards to 30,000 feet accompanied by occasional shower activity at the surface.

c. Tertiary winds occur daily just after sunrise and sunset. They may produce a rapid change of wind direction with marked increase in speed, with a duration of about 30 minutes. Direction depends on the thermal low, and speed depends on the gradient.

d. When the pressure gradient between El Centro and North Island reaches 7-10 mb in conjunction with a temperature gradient of 18^{o} F or more, Yuma will experience westerly surface winds of 15 to 25 knots. However, the passage of a well developed trough at 700 mb through the local area may drop the gradient required to as little as 3-5 mb.

e. Thunderstorms will form along the leading edge of a tight dewpoint gradient (warm side), at 500 millibars when the wind flow is perpendicular to that gradient (cold to warm).

f. When a Sonora condition is in evidence, and the low level flow is easterly at 15 knots or greater, thunderstorms (orographic) will intensify over the Gila Mountains to the southeast of Yuma. This activity normally develops by mid-afternoon with the possibility of some cells moving over the station.

g. Winds aloft (between 2,000-5,000 feet), of 25-30 knots showing on an early morning VAD wind profile will generally result in strong winds on the surface after 0800L-1000L, when the inversion breaks.

h. With dry surface conditions and a sustained westerly surface wind of 22 knots or greater, the surface visibility will frequently be reduced to less than 3 miles in blowing dust.

i. Intense thunderstorms moving northwestward across the sand dunes to the southwest or west of the station will often reduce surface visibility to less than 3 miles in blowing dust for 15 to 20 minute periods.

j. Air mass thunderstorm possibility increases as the 500 mb isoheights become more perpendicular to the -20^{o}C or warmer dewpoint. Where the flow is from dry to moist (moist being a -10^{o}C or warmer dewpoint), thunderstorms are definite. Dewpoint depressions are of no value using this rule.

SECTION IV

SPECIALIZED FORECASTS

1. With emphasis on training within the aviation community, providing products, or filling special requests becomes a routine affair. Below are listed eight specialized products issued to weather customers of MCAS Yuma:

a. Sun Angles The sun azimuth and altitude (elevation), is provided in degrees and minutes for each 5 minutes the sun is above the horizon. This data is produced by the Naval Observatory in Washington, D.C., on a yearly basis. The data can be computed by using the SLAP program. This information is used by air crews when planning attack angles.

b. Lunar Angles The moon angle, azimuth and altitude (elevation), is provided in degrees and minutes for each 4 minutes the moon is above the horizon. This data is used by helicopter pilots for planning night flying missions with night vision goggles. This information is provided by the Naval Observatory in Washington, D.C., on an annual basis. This data can be computed by using the MIDDS or the MOSS.

c. Sound Focus (SOCUS) This program forecasts sound propagation in the atmosphere, permitting the user to determine whether atmospheric conditions favor large scale refraction of sound toward populated areas during explosive exercises. Data input requirements consist of weight of explosive device and location of detonation.

d. D-Values Provides computations of deviation value profiles from the normal atmosphere, used in setting of pressure-bomb detonation altitudes.

e. Radiological Fallout The program used will forecast patterns of radiological fallout which may be used to determine unit maneuvering in the event of a nuclear burst. The output diagram reflects variable levels of radiation at a user defined time period. The levels of radiation can be set by the user.

f. Aircraft Icing This product forecasts aircraft ice accretion levels, probabilities, and intensities at various intervals.

g. Vapor Liquid Substance (VLS) Tracking Program This program assists in forecasting of patterns of chemical fallout which may be used to determine unit maneuvering in the event of chemical warfare.

h. Electro-Optical Tactical Decision Aid (EOTDA) EOTDA is a software model that predicts the performance of air-to-ground weapons systems and direct view optics based on environmental and tactical information. Performance is expressed primarily in terms of maximum detection or lock-on range. The EOTDA supports systems in three regions of the spectrum: infrared, visible, and laser. EOTDA supports specific menu targets and 9 classes of generic targets.

SECTION V

ENVIRONMENTAL EFFECTS

1. Environmental Effects The Yuma area weather has little effect on flight operations or weapons training. The following section describes those conditions that occasionally affect operations and training.

a. Surface Winds Since many different types of aircraft use MCAS Yuma for flight training, gusty surface winds pose a great threat to flight operations. Since most military aircraft use runways 03 or 21, the probability of encountering a significant crosswind is increased. Forecasters must strive to provide the maximum amount of lead time possible in forecasting strong gusty winds to ensure maximum safety precautions during operations.

b. Thunderstorms Thunderstorm activity, specifically the lightning associated with this phenomena, presents a possible threat to aircraft operations. Current station directives dictate that neither ordnance loading or aircraft refueling will be conducted while thunderstorms with associated electrical activity are within a radius of 10 miles of the station.

c. Turbulence This office provides weather briefings for aircraft operating out of Laguna AAF at Yuma Proving Ground. As directed by Army regulations, their aircraft cannot operate in any area(s) included in a SIGMET WARNING for confirmed or forecasted severe turbulence.

d. Dust Devils Dust devils are common over the southwest deserts. They are vigorous whirlwinds usually of short duration. Diameters range from 10 feet to greater than 100 feet. Their average height is about 600 feet, but few have been observed to rotate as high as several thousand feet. They have been observed to rotate anti-cyclonically as well as cyclonically. Dust Devils are best developed on a hot, calm afternoon with clear skies and in a dry region where intense surface heating causes a very steep temperature lapse rate in the lower few hundred feet of the atmosphere. Dust devils have been known to occasionally create brief moderate and even severe turbulence for light aircraft passing through them.

e. Blowing Dust As with any lower desert region, blowing sand and dust can be a significant problem to flight operations and training. The sand dunes become a factor with a sustained surface wind of 22 knots or greater from the west through northwest. This condition will reduce visibility to 3 miles or less in blowing dust or sand.

f. Flash Floods Due to the lack of proper drainage systems aboard the base and the surrounding area, flash floods are a major problem during the rainy season.

SECTION VI

TROPICAL STORM/HURRICANE KATHLEEN, 7-10 SEPTEMBER 1976

Hurricane Kathleen began forming on the 6th of September 1976, near 05^{o} N 109^{o} W, about 550 miles south-southwest of La Paz (located near the southern tip of the Baja Peninsula). After 24 hours, the storm became more organized and tracked north-northwest.

On the 8th of September, Yuma went from clear to 20,000 overcast during the morning. By the morning of the 9th of September, as the storm moved closer, ceilings had decreased to 16,000 feet and gradually lowered to 7,000 feet by the day's end. Light rainshowers were prevalent throughout the day, while the surface winds remained variable.

On 10 September, the ceiling lowered to 5,000 feet and the winds became 60^{o} degrees, showing Yuma to be in the northeast quadrant of the storm. Throughout the morning the winds veered, and by 0700L began increasing in speed. Light rainshowers were intermittent until 0800L when it became steady rain. Thunderstorms began at 0840L and visibility's were reduced to one half mile in blowing sand(caused by the continual increasing wind speed), and occasional moderate precipitation. By 1000L, the winds had veered to160^{o} and gusts to 62 knots were recorded. At this time, the right rear quadrant of the storm passed over the Yuma area, the thunderstorm activity ended, and the winds continued to veer and decrease in speed. Rainshowers ended by 1400L, and blowing sand ended by 1800L. The surface winds became 210^{o} at 10 knots by 2100L, and only scattered clouds remained as the storm weakened rapidly.

Of the reporting stations affected, Yuma recorded the highest winds, with a gust to 62 knots, and the least rainfall, with only .16 inches being recorded. The heaviest precipitation occurred in the southern California coastal mountains from San Bernadino south into northern Baja. Amounts of up to 10 inches or more fell in the mountain area just west of El Centro, the Salton Sea, and Thermal California. These heavy concentrations of rainfall caused severe, damaging flash floods in the mountains and along the western edge of the Imperial Valley.

1. <u>CHRONOLOGY OF KATHLEEN</u>

The following chronology is a brief summation of the formation, life, and dissipation of Hurricane Kathleen:

a. 070600Z, tropical depression, winds 30 knots
b. 071800Z, tropical storm, winds 35 knots, gusts to 45 knots
c. 080600Z, tropical storm, winds 55 knots, gust to 65 knots
d. 081800Z, tropical storm, winds 50 knots, gust to 60 knots
e. 090600Z, tropical storm, winds 50 knots, gust to 60 knots
f. 091800Z, tropical storm, winds 45 knots, gust to 55 knots
g. 100000Z, hurricane, winds 70 knots, gust to 80 knots
h. 100600Z, tropical storm, winds 50 knots, gust to 80 knots
i. 101200Z, tropical storm, winds 35 knots, gust to 45 knots
j. 101800Z, forecast position from final warning.

2. <u>TRACK OF KATHLEEN</u>

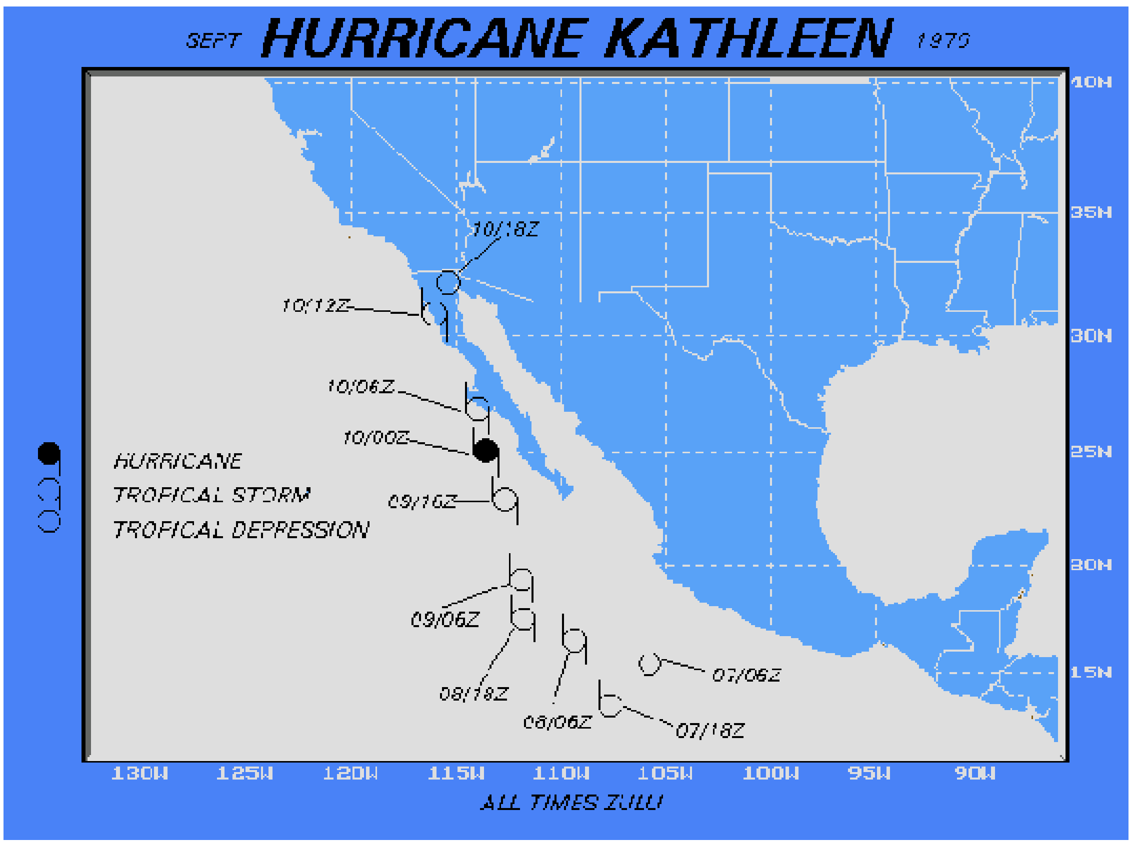


Figure 6-1

TROPICAL STORM/HURRICANE NORA, 16-26 SEPTEMBER 1997

Hurricane Nora began forming on the 16th of September 1997, near 13° N 102° W, about 270 miles southwest of Acapulco. After 12 hours, the storm became more organized and began tracking northwest.

On the 23rd of September, Yuma went from clear skies to 20,000 scattered. By early morning of the 24th of September a ceiling formed at 20,000 feet and gradually lowered to 12,000 feet by that afternoon with a temporary ceilings of 5,000 feet and light rainshowers. Later that evening Yuma went overcast at 20,000 feet with more continuous rainshowers and a ceiling at 8,000 feet.

On the morning of the 25th ceilings gradually lowered to 5,500 feet with moderate rainshowers and sustained winds of 10-12 knots developing. Thunderstorms developed on station around 1000L with heavy rainshowers and sustained winds of 15 knots with gusts of 24-26 knots. Ceilings associated with the thunderstorms were down to 1,500 feet and visibility down to ½ mile. Rainshowers and thunderstorms ended around 1300L with the visibility gradually becoming unrestricted shortly thereafter. The high winds continued throughout the afternoon with sustained winds of 25-30 knots and the max gust of 47 knots from 160° occurring at 1406L. Yuma remained overcast at 3,000 feet throughout the afternoon with isolated rainshowers. By 1600L winds were sustained at 16-18 knots and by 1800L winds were down to 10-12 knots. Rainshowers ended around 1900L and by 2000L the ceiling began to raise. By 2200L the ceiling was at 12,000 feet and the winds were light and variable.

Early on the morning of the 26th the ceiling went from 12,000 feet to 20,000 and by 1800L Yuma went scattered. By 2100L that night Yuma skies were clear.

3. <u>CHRONOLOGY OF NORA</u>

The following chronology is a brief summation of the formation, life, and dissipation of Hurricane Nora:

1. 161500Z, tropical depression, winds 30 knots, gusts to 40 knots
2. 171500Z, tropical storm, winds 55 knots, gusts to 65 knots
3. 181500Z, hurricane, winds 75 knots, gusts to 90 knots
4. 191500Z, hurricane, winds 85 knots, gusts to 105 knots
5. 201500Z, hurricane, winds 65 knots, gusts to 80 knots
6. 211500Z, hurricane, winds 110 knots, gusts to 135 knots
7. 221500Z, hurricane, winds 110 knots, gusts to 135 knots
8. 231500Z, hurricane, winds 90 knots, gusts to 110 knots
9. 241500Z, hurricane, winds 75 knots, gusts to 90 knots
10. 250300Z, hurricane, winds 75 knots, gusts to 90 knots
11. 251500Z, tropical storm, winds 60 knots, gusts to 80 knots
12. 260300Z, tropical depression, winds 30 knots, gusts to 40 knots

4. <u>TRACK OF NORA</u>

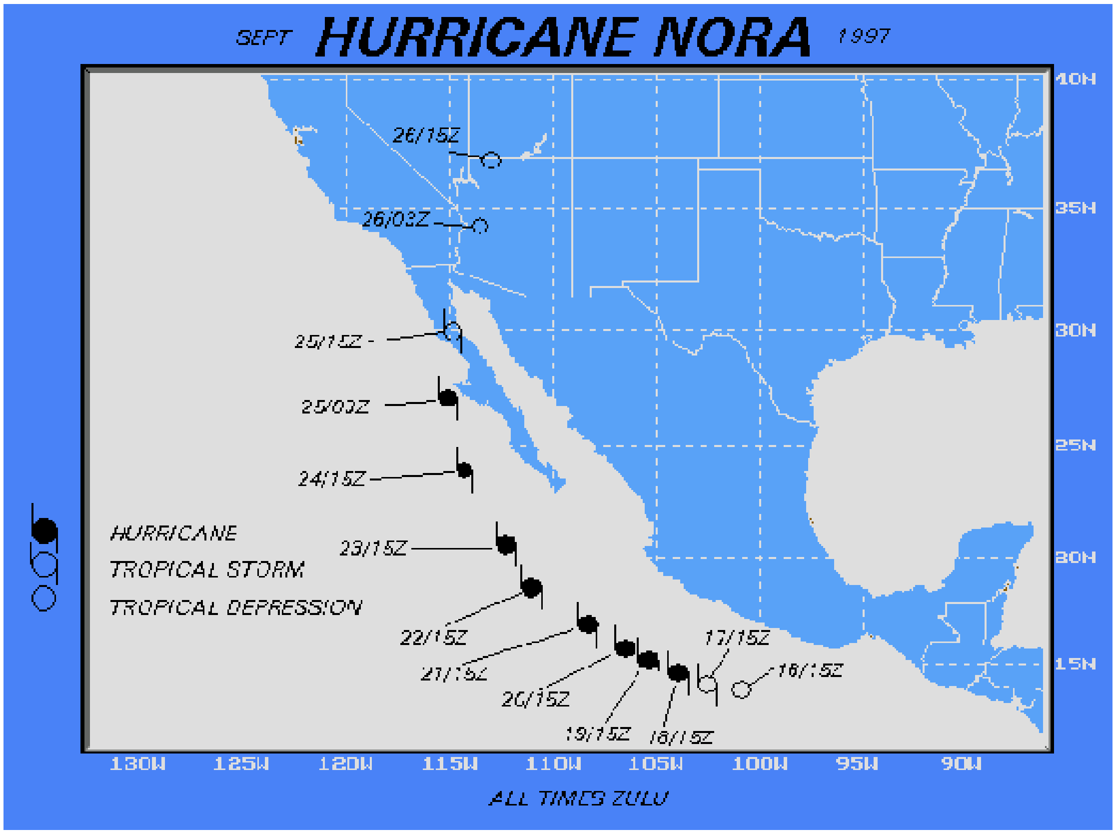


Figure 6-2

SECTION VII

AIRCRAFT IDENTIFICATION

AV-8B "HARRIER"

MISSION: To provide close air support, tactical reconnaissance, night attacks, and provide limited air defense for Marine Expeditionary Forces.

DESCRIPTION: The AV-8B is a single-seat V/STOL single engine quad-exhaust attack aircraft. There are six under-wing weapon stations and a General Electric five-barrel 25mm cannon. Avionics and equipment include a nose-carried Hughes AN/ASB-19(V)2 or (V)3 Angle Rate Bombing Set with TV and laser target seeker and tracker, radar warning receiver and flare/chaff dispenser. The NIGHT ATTACK version comes equipped with a FLIR in nose, night vision goggles for the pilot, wide view HUD, color head-down displays, and other changes. MCAS Yuma supports four AV-8B squadrons.

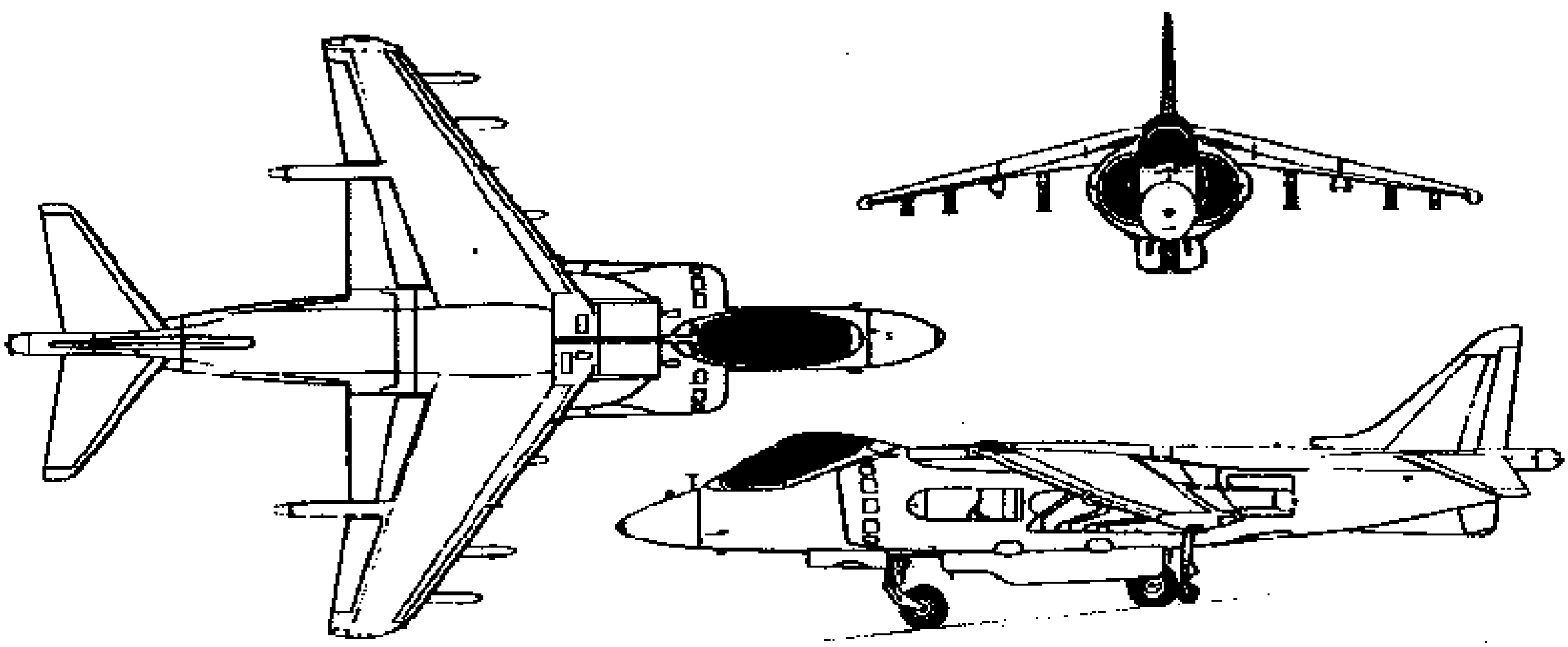
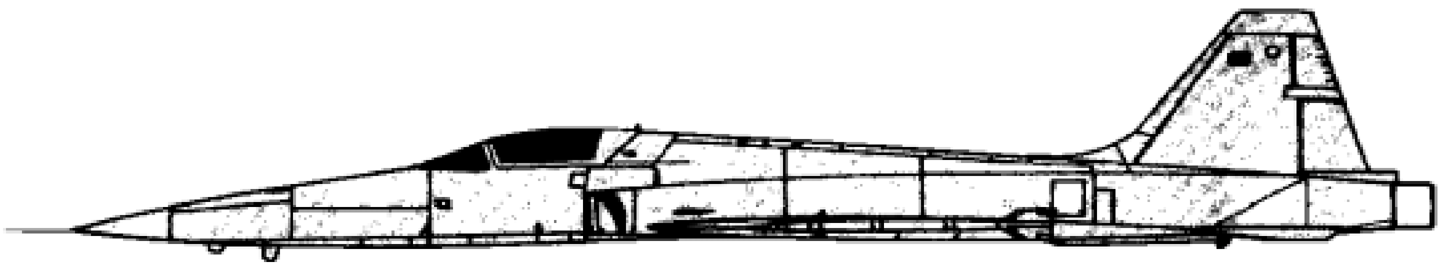


Figure 7-1
F-5E "TigerII"

MISSION: To provide reconnaissance and as tactical fighter. Here at MCAS Yuma the F-5E is used as an aggressor aircraft, simulating various threat aircraft types for the purpose of training.

DESCRIPTION: The F-5E is a single-seated twin engine aircraft. There is one under-fuselage and four under-wing pylons for missiles, bombs, and rocket packs etc.. The F-5E comes equipped with an Emerson AN/APQ-159 radar. MCAS Yuma supports one F-5E squadron.



F—5 A/B FREEDOM FIGHTER

Figure 7-2

F/A 18D "Hornet"

MISSION: To provide close air support, tactical and aerial reconnaissance, night and all weather attacks, and provide air defense for Marine Expeditionary Forces.

DESCRIPTION: The F/A-18D is a two-seated double engine, dual purpose airplane. There is one under-fuselage, two air intake, four under-wing, two wingtip weapon stations, and one M61 20mm cannon. The F/A-18D has a Hughes AN/APG-65 radar, CRT cockpit display with HUD, radar warning receiver, laser spot tracker, strike camera, and FLIR on air intake stations for attack/strike role. MCAS Yuma supports many F/A-18D squadrons throughout the year though there are none permanently on station.

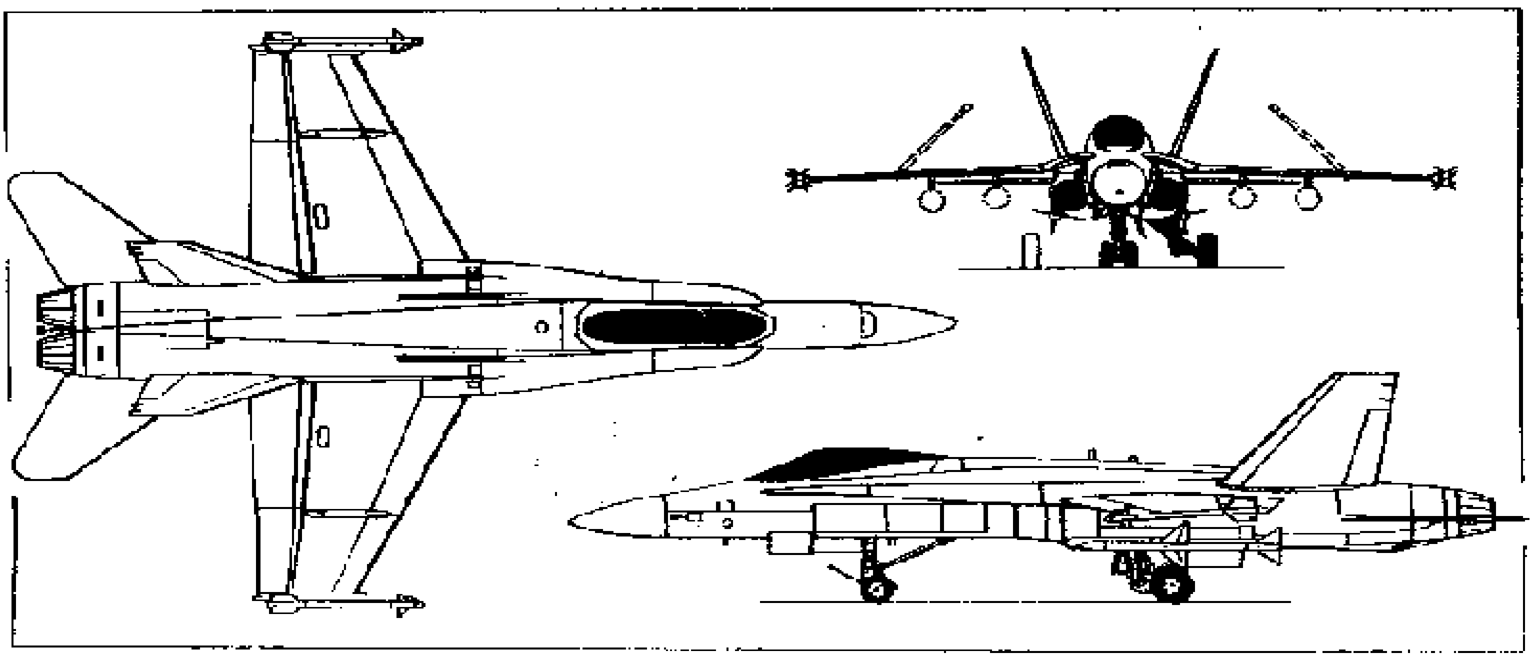


Figure 7-3

EA6-B "PROWLER"

MISSION: Conduct airborne electronic warfare (EW) in support of Fleet Marine Force Operations.

DESCRIPTION: The EA-6B is a four-seat, all weather, twin-turbojet EW aircraft that employs a tactical jamming system consisting of on-board receivers and up to five externally mounted jamming pods to degrade enemy air defenses. It is capable of aerial refueling and is deployable from either land bases or aircraft carriers.

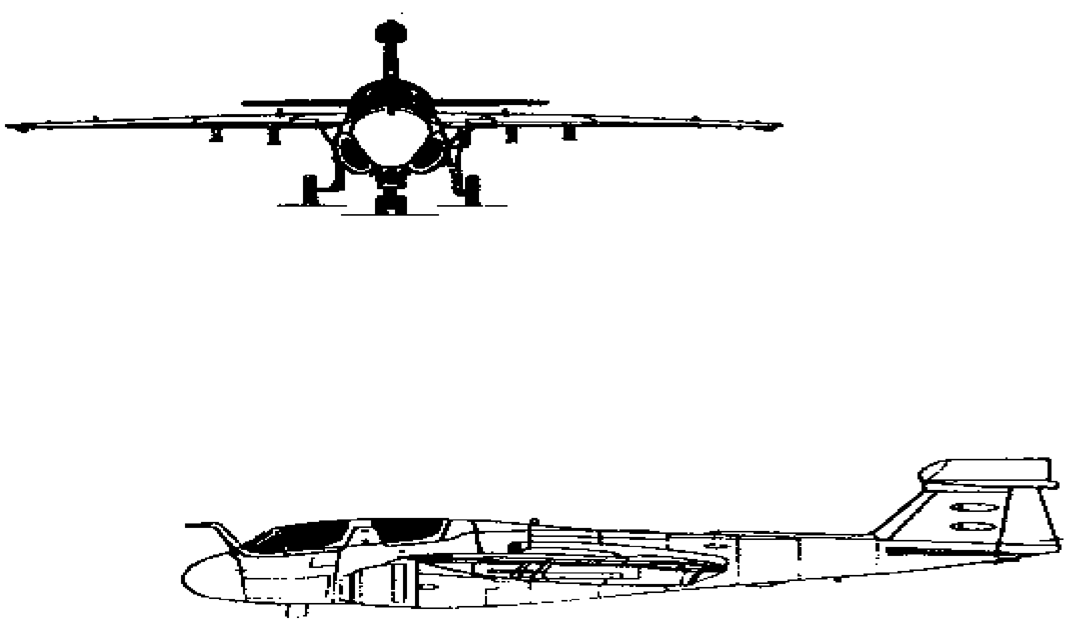


Figure 7-4

KC-130 "HUERCULES"

MISSION: Provide aerial refueling and assault air transport of personnel, equipment and supplies in support of Fleet Marine Forces and conduct such other air operations as may be directed.

DESCRIPTION: The KC-130 is a four engine, turboprop transport especially configured to enable it to perform its primary role as an aerial refueler. Carrying a crew of six or seven, the KC-130 can fly 1,000 miles and transfer 31,000 pounds of fuel. The KC-130 can also be used as a tactical transport carrying 92 ground troops or as an ambulance carrying 74 litters.

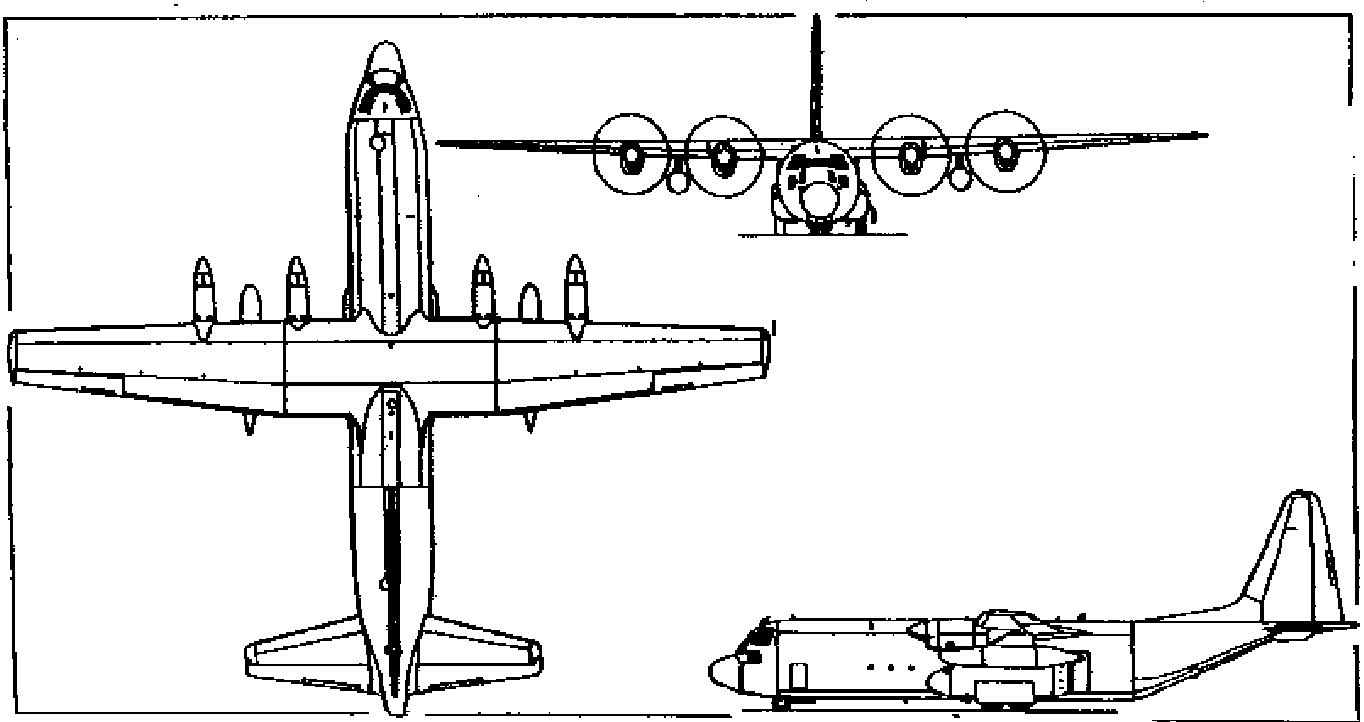


Figure 7-5

UC-12A/B "KING AIR 200"

MISSION: To provide transportation of passengers and/or light cargo.

DESCRIPTION: The UC-12A/B are manufactured by Beech Aircraft Corporation, and are all-metal, low wing, twin turbo-prop, T-tail monoplanes. The flight and cabin compartments are pressurized for high altitude flight. Along with a crew of three, the UC-12A/B can carry seven passengers, and up to 410lbs of cargo or 2,500lbs of cargo. The UC-12A/B has a maximum range of over 1,600 miles at a maximum altitude of 31,000 feet and a true airspeed of 245 knots. MCAS Yuma supports two UC-12A/B aircraft that are permanently on station.

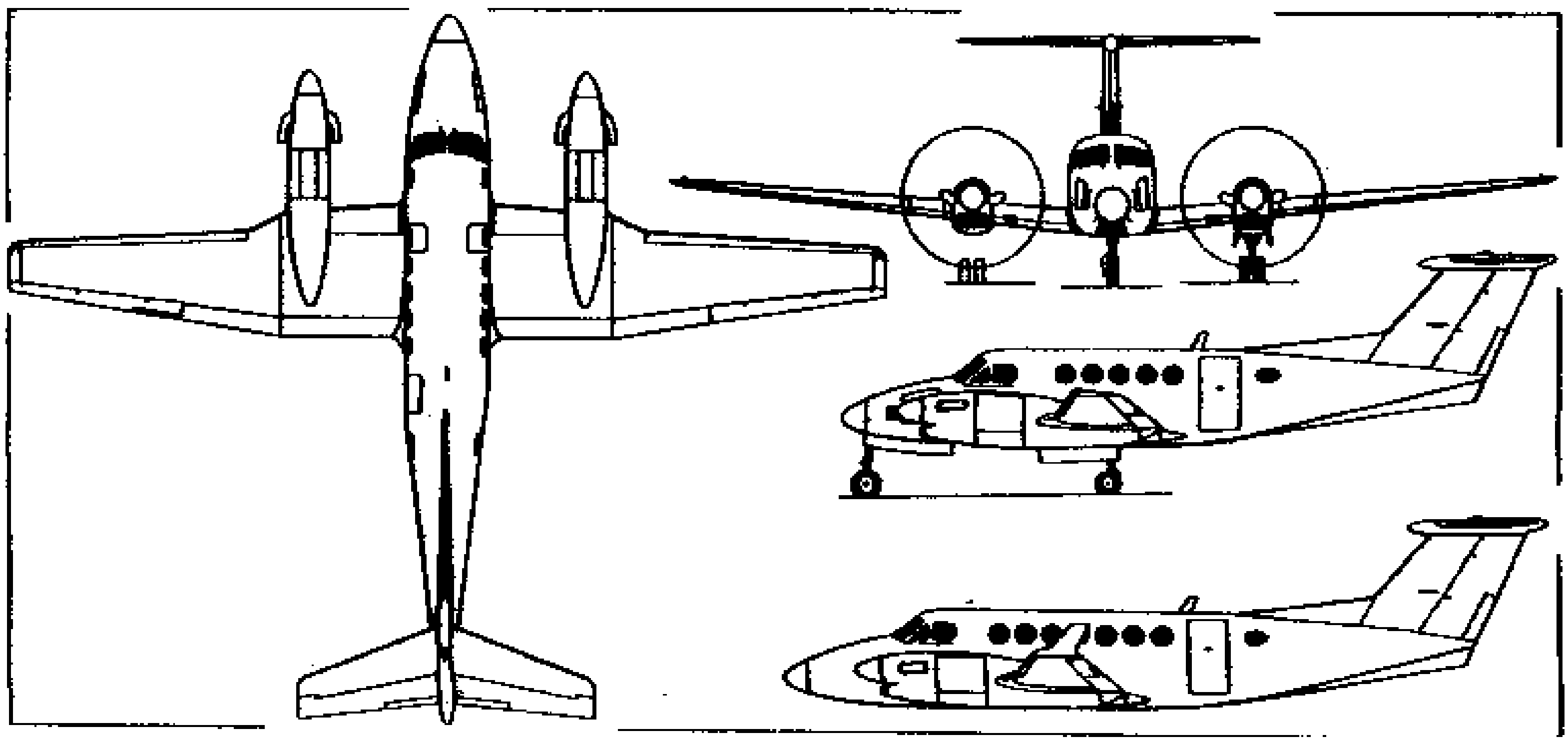


Figure 7-6

UH-1N "HUEY"

MISSION: To provide for the Search and Rescue (SAR) of downed aircraft and transportation for emergency medical patients.

DESCRIPTION: The UH-1N is manufactured by Bell Aviation. It is powered by a Pratt & Whitney PT6T-3B Twin Pac with 1,800 horsepower in each engine. The UH-1N carries a pilot and up to 14 passengers. The UH-1N has a cruise speed of 115 mph and a max speed of 127 mph. The UH-1N has a climb speed of 1,320 ft/min with a ceiling of 13,000 ft. There are two UH-1N helicopters on station for use as SAR aircraft.

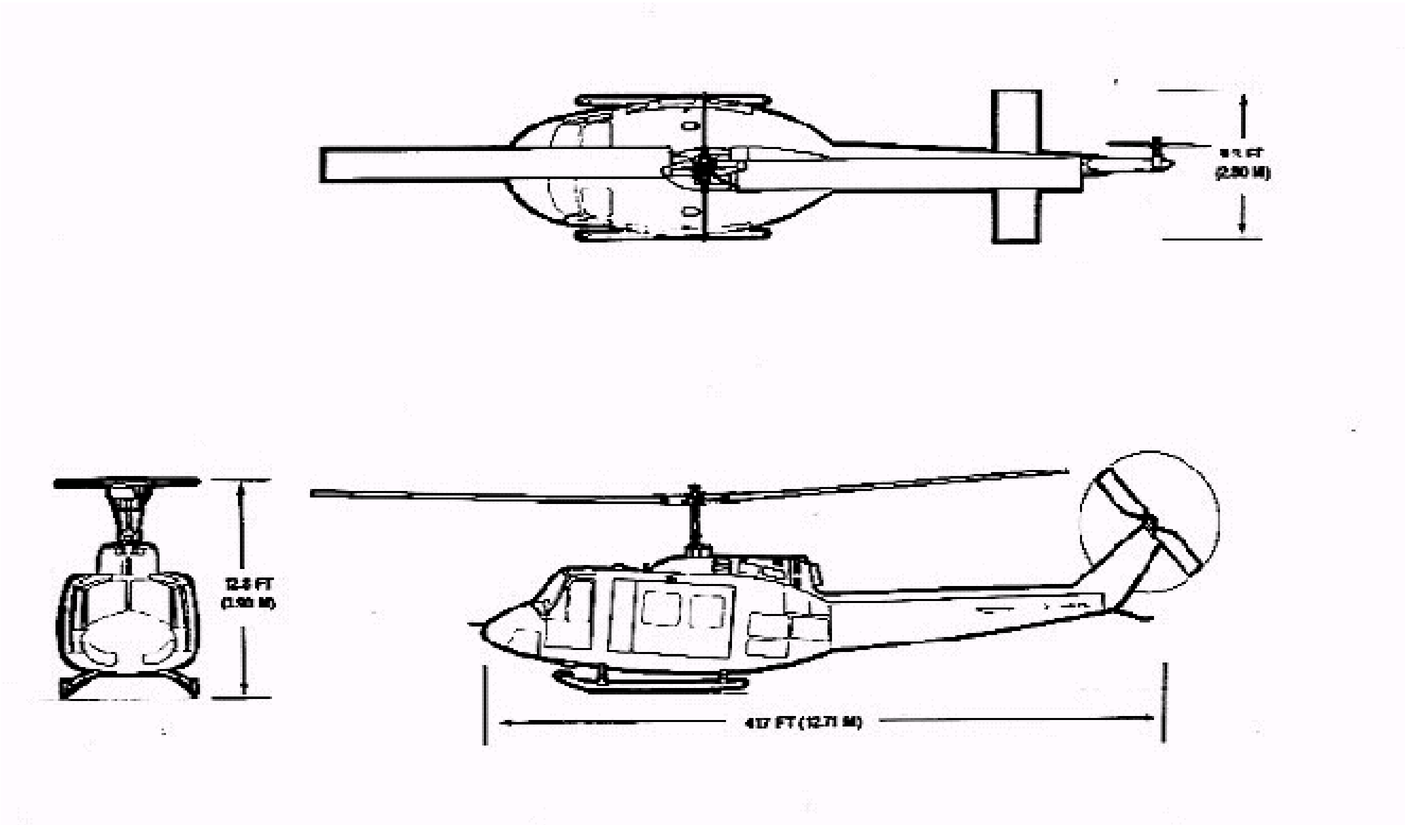


Figure 7-7

AH-1W "SUPER COBRA"

MISSION: To provide close-in fire support and fire support coordination in aerial and ground escort operations during the ship-to-shore movement and within an objective area.

DISCRIPTION: The AH-1W is a two-seat, twin-engine, single rotor, attack helicopter. It has a flexible chin-mounted 20mm nose turret and four stub wing ordnance stations capable of carrying gun and rocket pods. The AH-1W is an attack helicopter gunship. The AH-1W, armed with the TOW missle system, has an anti-armor capability as well.

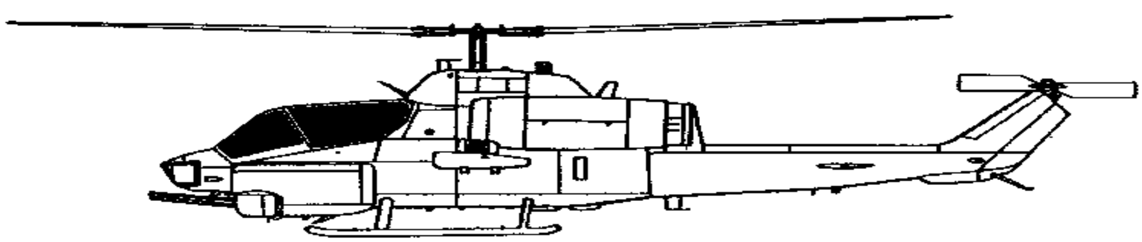


Figure 7-8

CH-53D "SEA STALLION" and CH-53E "SUPER STALLION"

MISSION: To provide helicopter transport of supplies, equipment and personnel for the landing force during ship-to-shore movement and within the objective area.

DESCRIPTION: The CH-53D (not pictured) are fully instrumented, all-weather, twin-engine, six bladed, single rotor helicopter with external range extension tanks. The rear tail rotor is straight up and down. It has a rear ramp for rapid loading and unloading of cargo and vehicles and an extermal cargo hook. They are built for Naval use with floating rotor and tail and are equipped with floatation gear. The CH-53E (pictured) is a fully instrumented, all-weather, three-engine, seven bladed, single rotor, heavy lift helicopter. The rear tail rotor is canted. It has a rear ramp for rapid loading and unloading of cargo and vehicles and an external cargo hook. The CH-53E is capable of lifting 93% of the combat essential equipment for a Marine division and can also retrieve all Marine tactical aircraft, except the EA-6B, including another CH-53E.

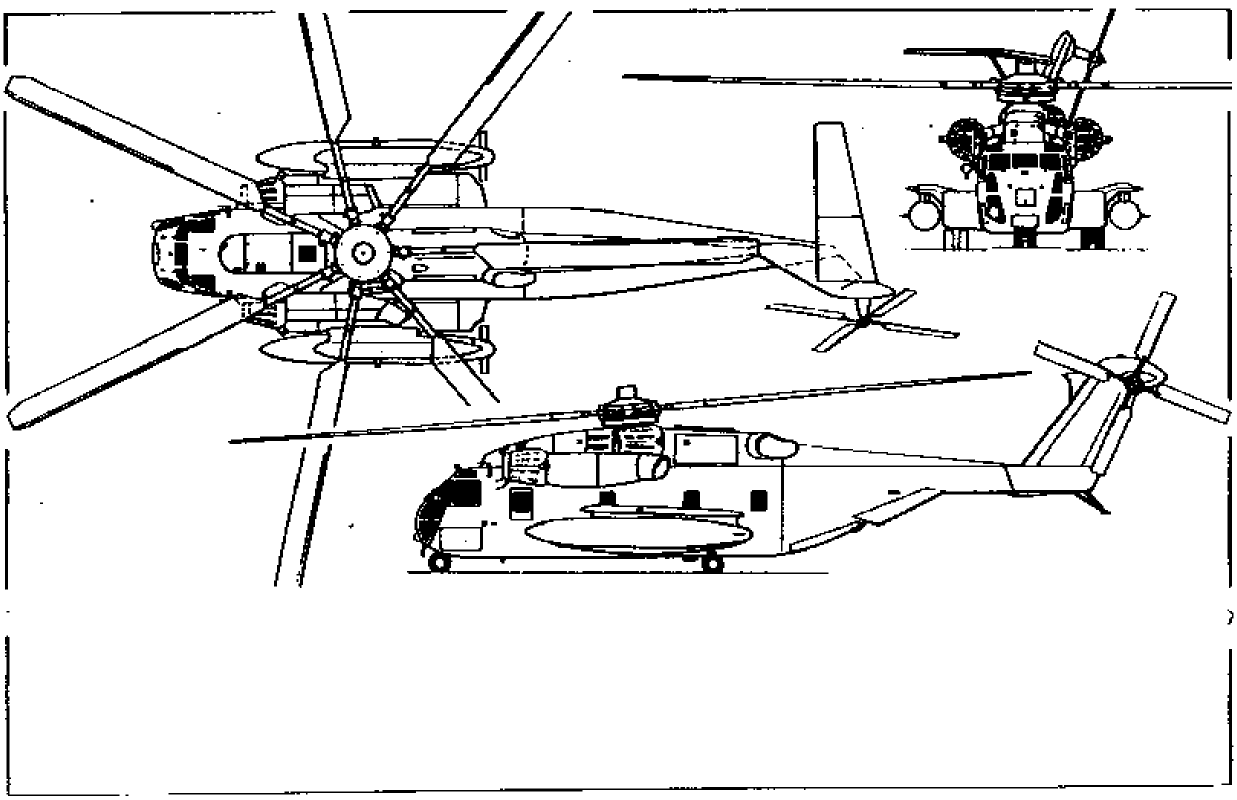


Figure 7-9

CH-46E "SEA KNIGHT"

MISSION: Provide helicopter transport of supplies, equipment and personnel for the landing force during ship-to-shore movement and within the objective area.

DESCRIPTION: The CH-46E is a fully instrumented, all-weather, twin-engine, tandem rotor helicopter. A rear landing ramp provides rapid loading and unloading of cargo and vehicles, while an external hook allows for cargo lift.

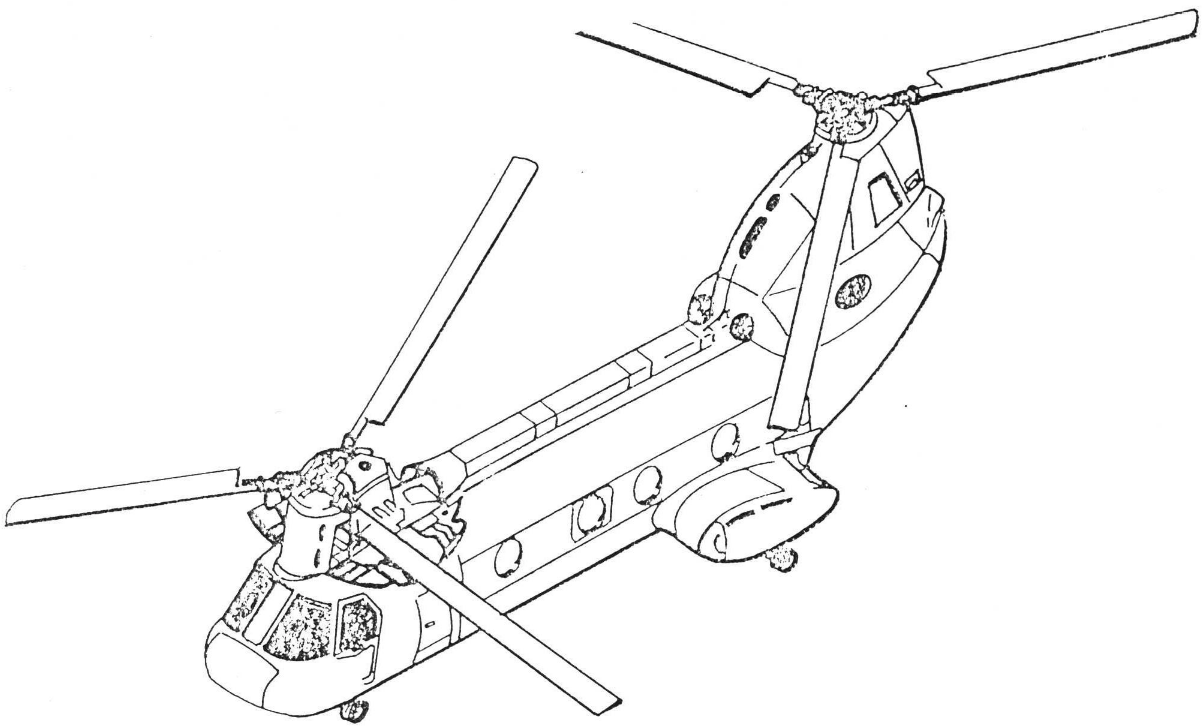


Figure 7-10

SECTION VIII

REFERENCES

1. The following references were used in the reconstruction of this handbook.

a. Summary of Meteorological Observations, MCAS Yuma, AZ.

b. Local Area Forecaster's Handbook, MCAS Yuma, AZ 10 August 1986.

c. Upper Wind Statistics Charts of the Northern Hemisphere, August 1959, 5-9 NAVAIR 50-1c-535, Volume I.

d. U.S. Navy Marine Climatic Atlas of the World, July 1956, 5-2 NAVAIR 50-1c-529, Volume II.

e. Mariners Worldwide Climatic Guide to Tropical Storms at Sea, March 1974, 5-20 NAVAIR 50-1c-61

f. Meridional Cross-section, Upper Winds Over the Northern Hemisphere, May 1952, 5-25 NAVWEPS 50-1c-537

g. Local Climatological Data, Annual Summary with Comparative Data for Yuma, AZ, NOAA.

h. A Surge of Maritime Tropical Air-Gulf of California to the Southwestern United States. NOAA TM NWS WR88, July 1973, Ira S. Brenner.

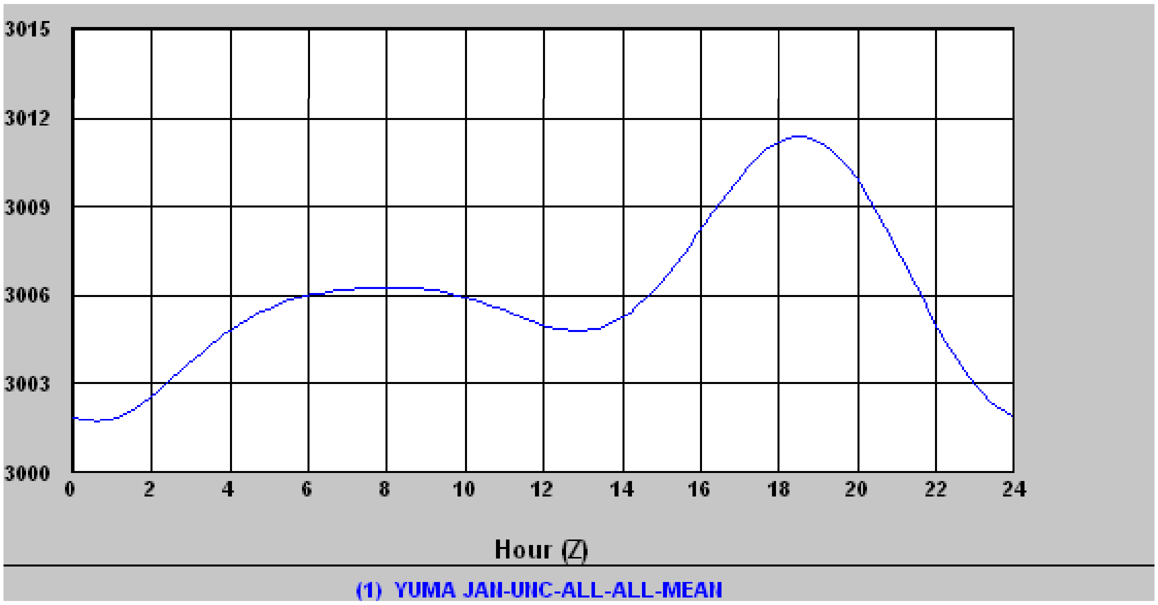
i. Southwestern United States Summer Monsoon Source-Gulf of Mexico or Pacific Ocean? NOAA TM NWS WR84, March 1973, John E. Hales, Jr.

j. The Arizona Monsoon, Technical Paper, 10 May 1985, John H. Tenharkel, NWS Phoenix, AZ.

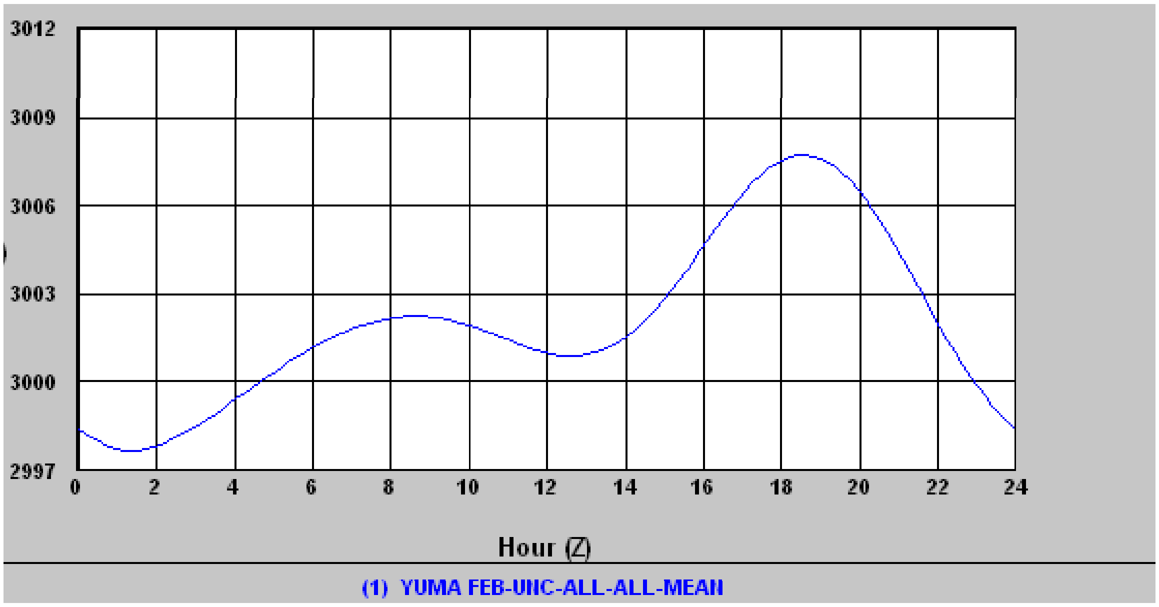
k. Southwestern Arizona Rainfall Event and Their Associated 500 MB Patterns, Paul R. Vukits, ASL Yuma Met Team.

APPENDIX

JANUARY

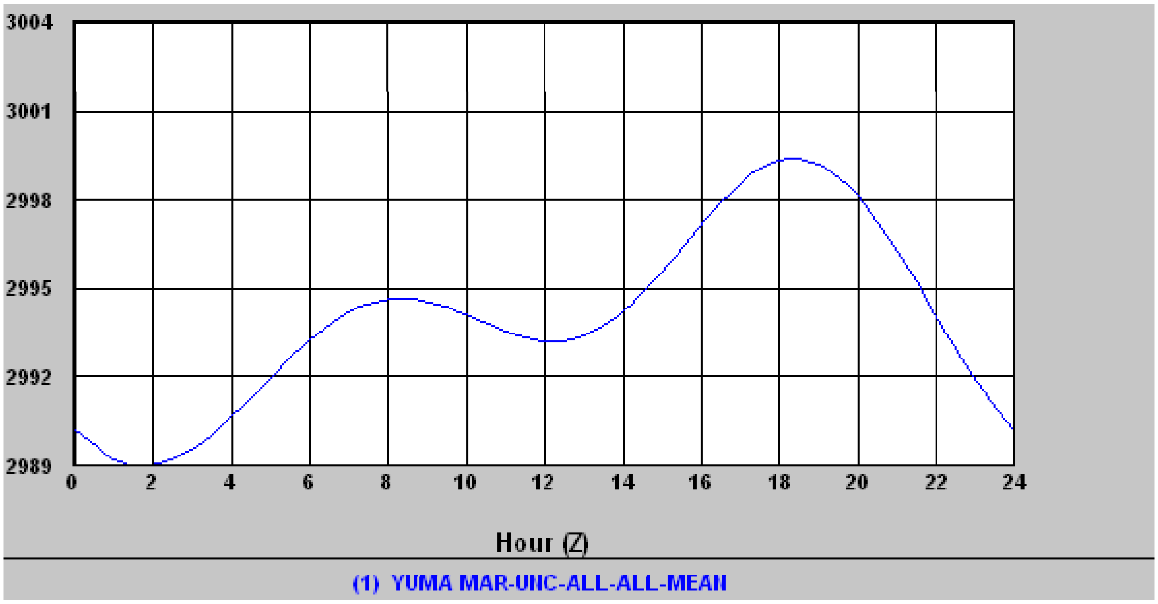

3015
3012
3009
3006
3003
3000
0
2
4
6
8
10
12
14
16
18
20
22
24
Hour (Z)
(1) YUMA JAN-UNC-ALL-ALL-MEAN

FEBRUARY



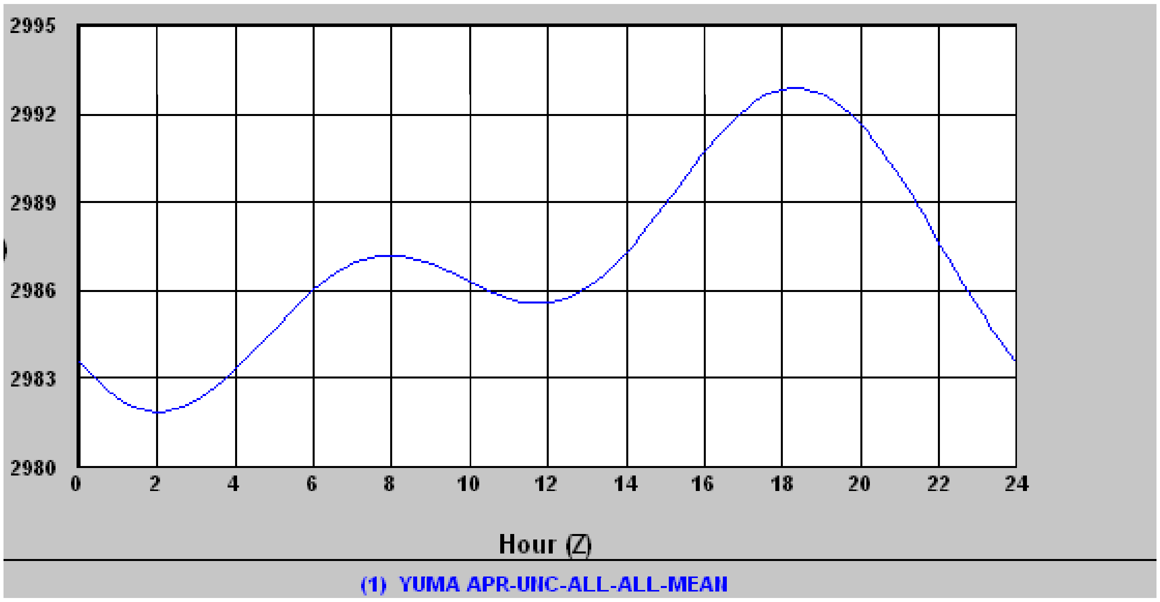
3012
3009
3006
3003
3000
2997
0
2
4
6
8
10
12
14
16
18
20
22
24
Hour (Z)
(1) YUMA FEB-UNC-ALL-ALL-MEAN

MARCH

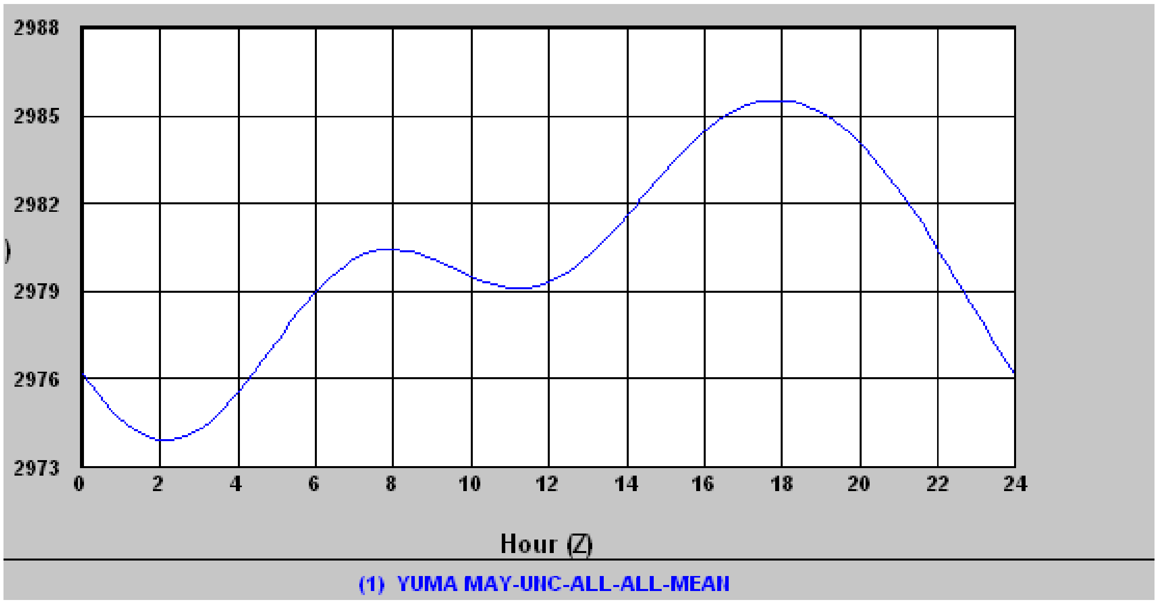


3004
3001
2998
2995
2992
2989
0
2
4
6
8
10
12
14
16
18
20
22
24
Hour (Z)
(1) YUMA MAR-UNC-ALL-ALL-MEAN

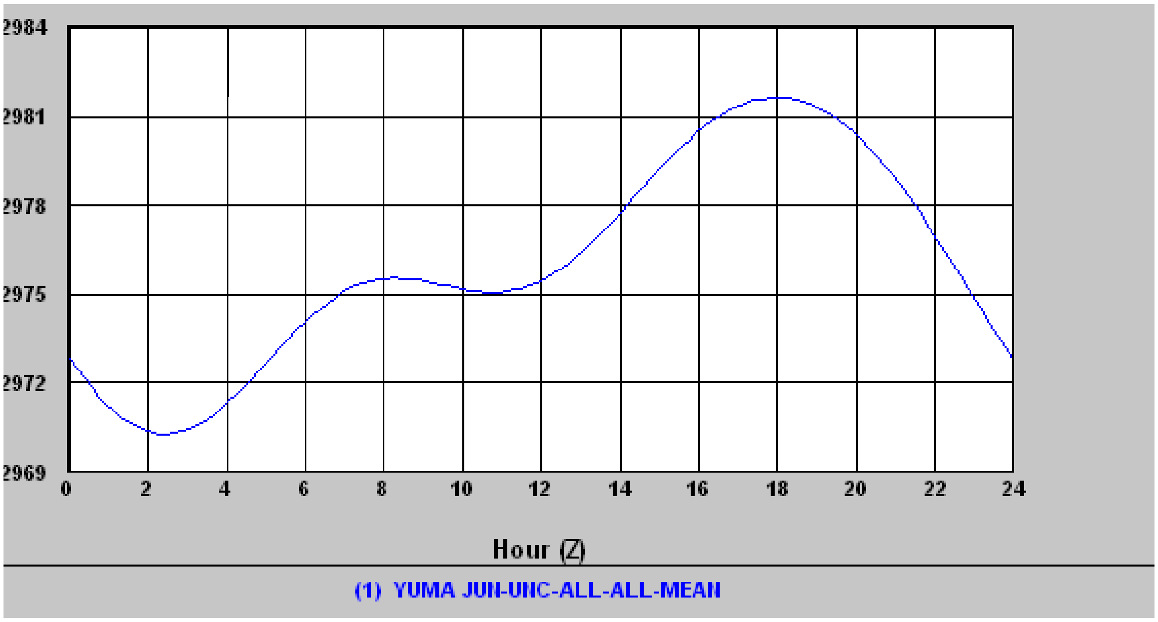
APRIL


2995
2992
2989
2986
2983
2980
0
2
4
6
8
10
12
14
16
18
20
22
24
Hour (Z)
(1) YUMA APR-UNC-ALL-ALL-MEAN

MAY

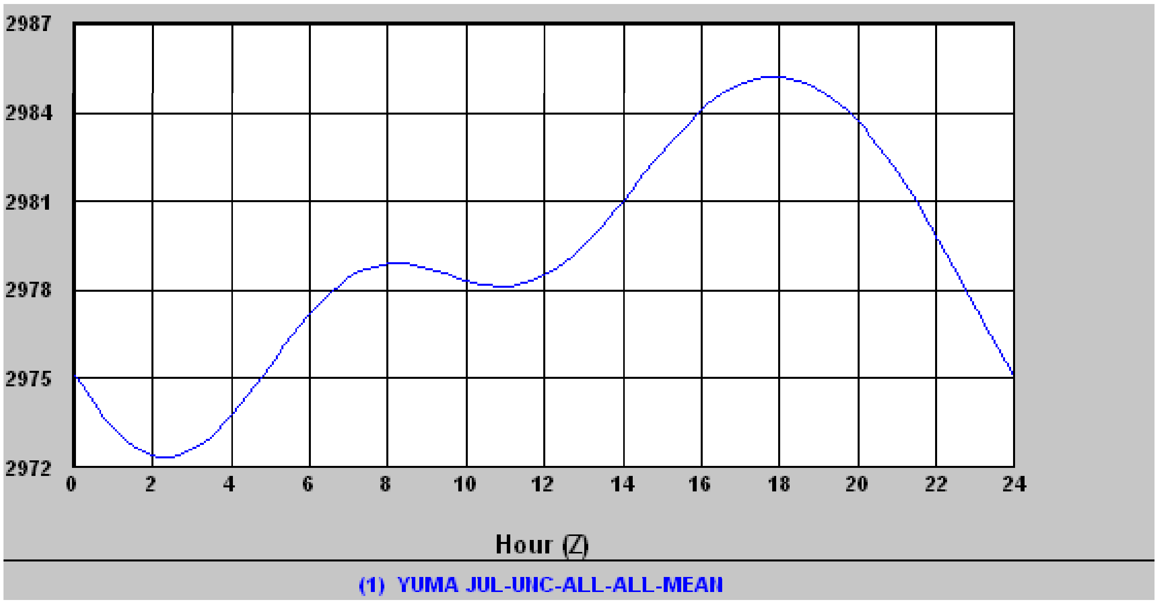

2988
2985
2982
2979
2976
2973
0
2
4
6
8
10
12
14
16
18
20
22
24
Hour (Z)
(1) YUMA MAY-UNC-ALL-ALL-MEAN

JUNE

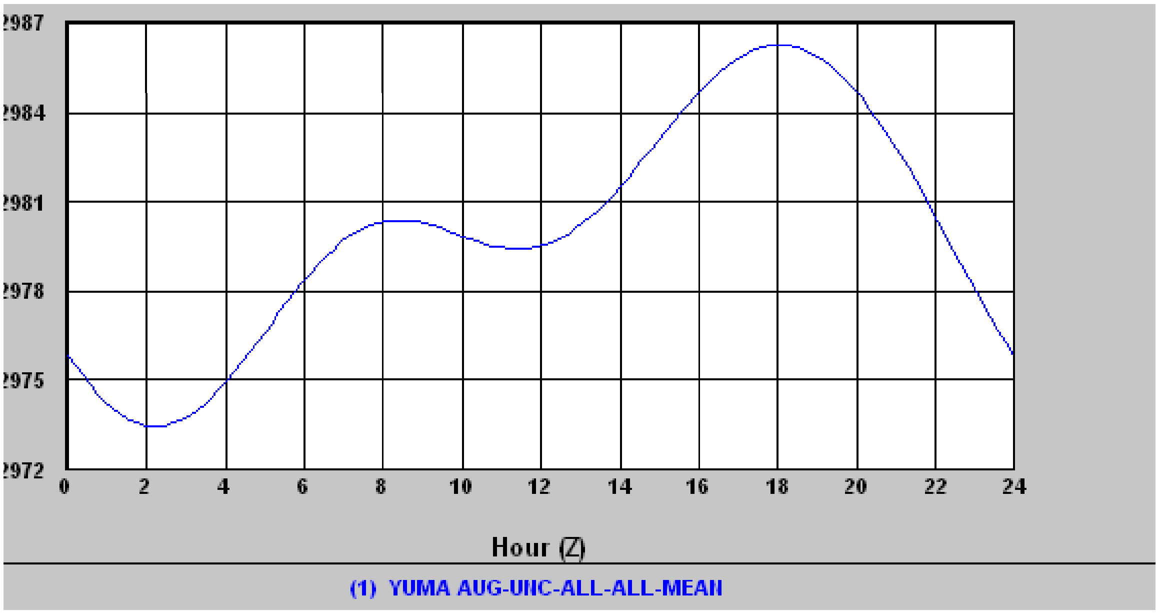


2984
2981
2978
2975
2972
2969
0
2
4
6
8
10
12
14
16
18
20
22
24
Hour (Z)
(1) YUMA JUN-UNC-ALL-ALL-MEAN

JULY

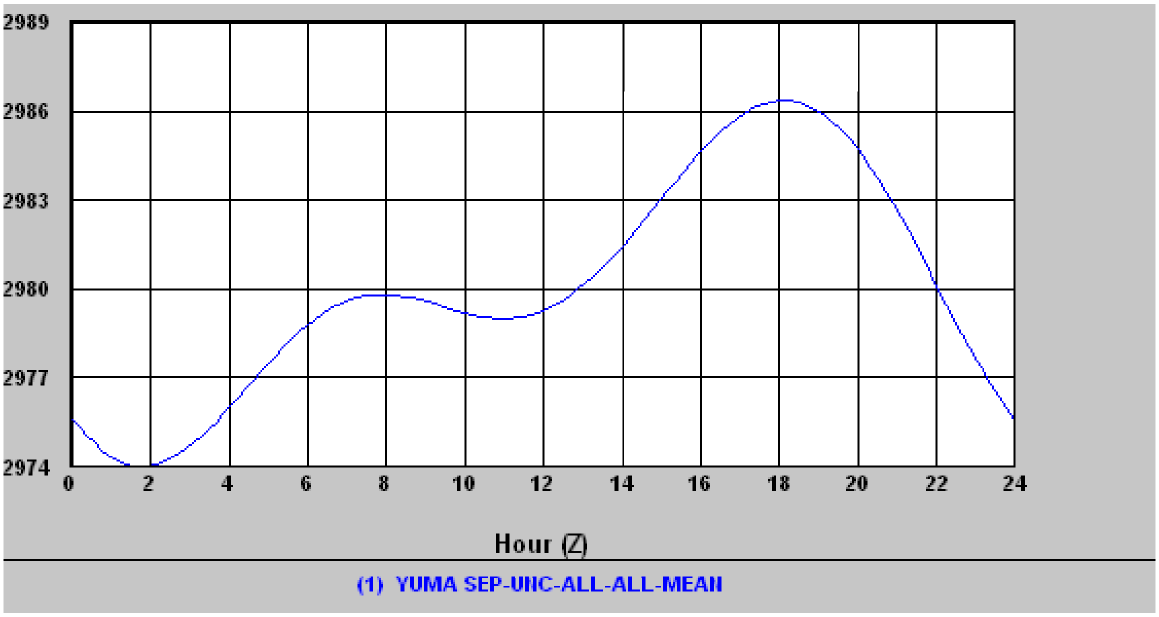

2987
2984
2981
2978
2975
2972
0
2
4
6
8
10
12
14
16
18
20
22
24
Hour (Z)
(1) YUMA JUL-UNC-ALL-ALL-MEAN

AUGUST



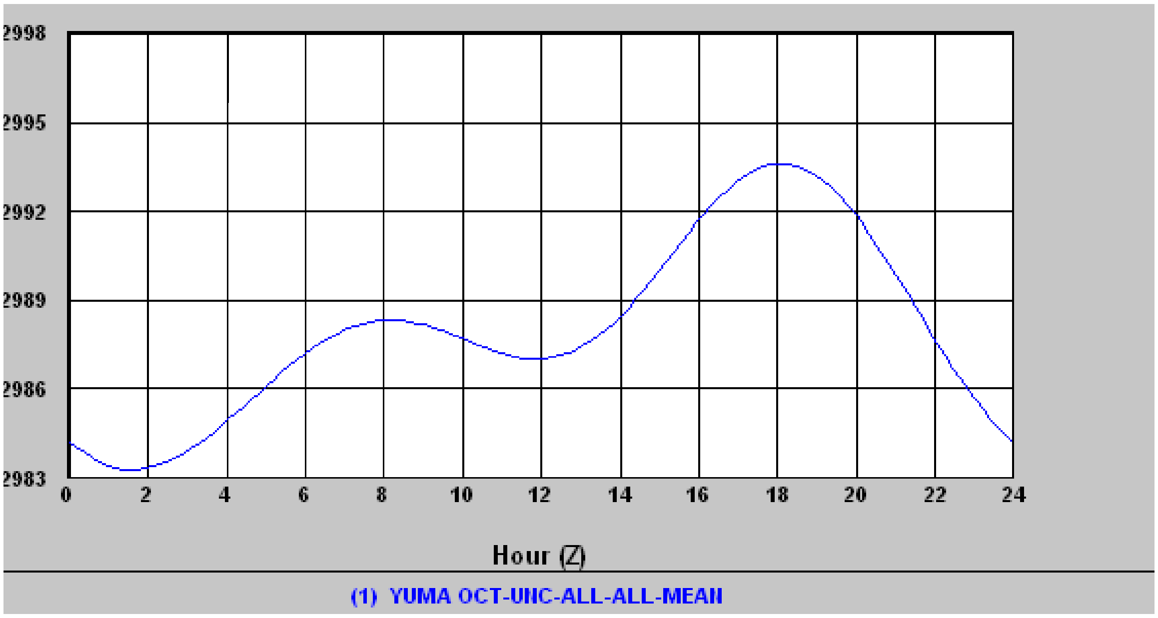
2987
2984
2981
2978
2975
2972
0
2
4
6
8
10
12
14
16
18
20
22
24
Hour (Z)
(1) YUMA AUG-UNC-ALL-ALL-MEAN

SEPTEMBER

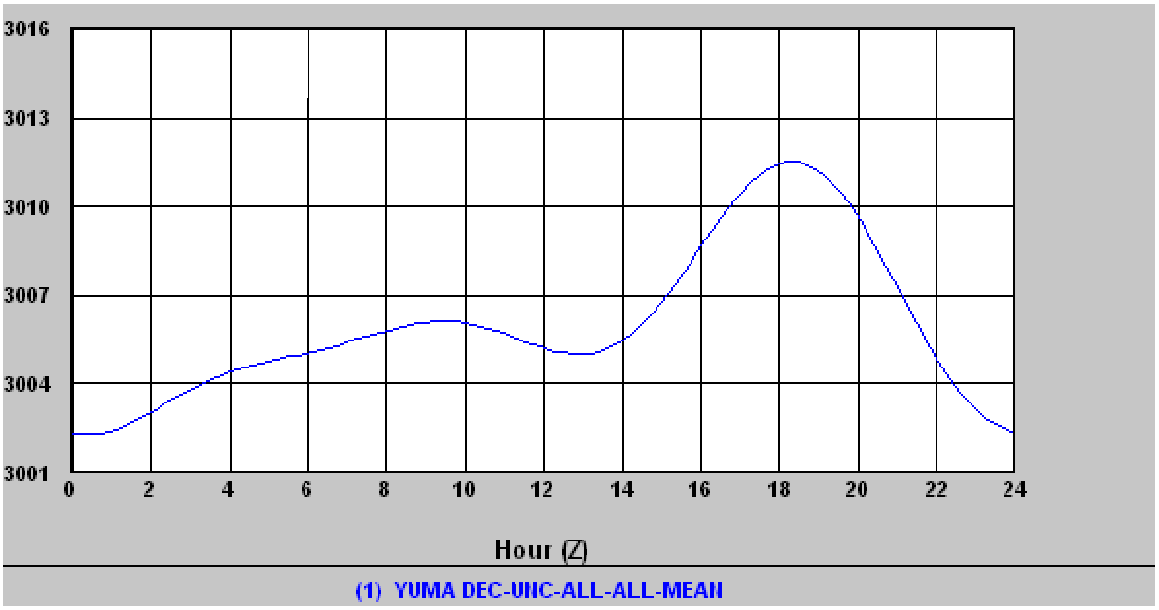


2989
2986
2983
2980
2977
2974
0
2
4
6
8
10
12
14
16
18
20
22
24
Hour (Z)
(1) YUMA SEP-UNC-ALL-ALL-MEAN

OCTOBER

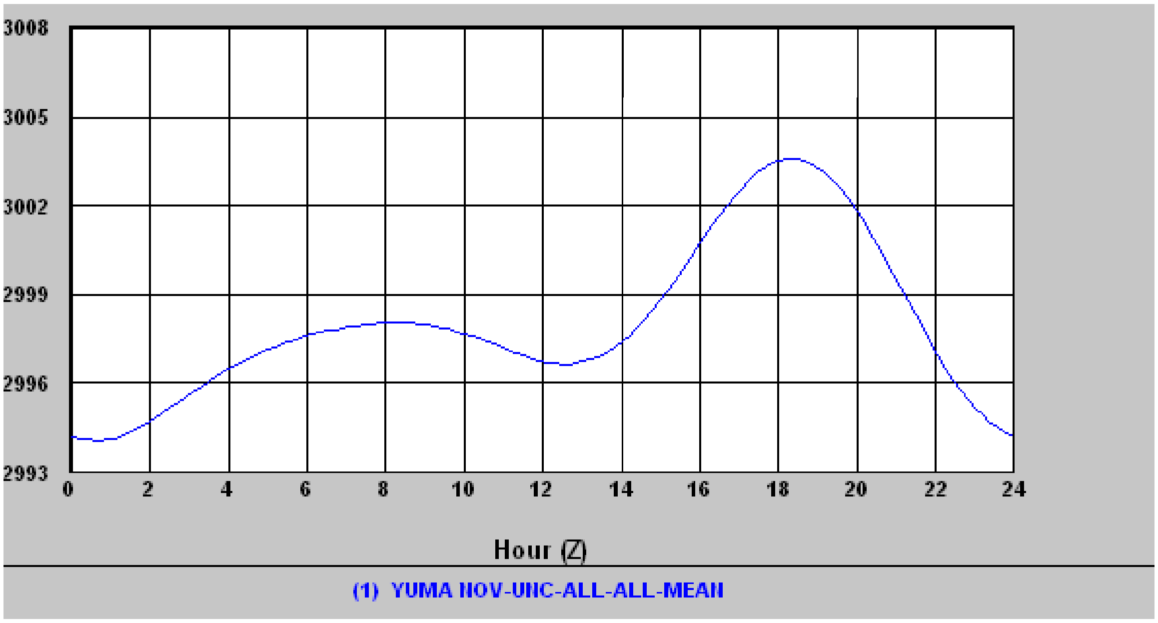

2998
2995
2992
2989
2986
2983
0
2
4
6
8
10
12
14
16
18
20
22
24
Hour (Z)
(1) YUMA OCT-UNC-ALL-ALL-MEAN

NOVEMBER



3016
3013
3010
3007
3004
3001
0
2
4
6
8
10
12
14
16
18
20
22
24
Hour (Z)
(1) YUMA DEC-UNC-ALL-ALL-MEAN

DECEMBER



3008
3005
3002
2999
2996
2993
0
2
4
6
8
10
12
14
16
18
20
22
24
Hour (Z)
(1) YUMA NOV-UNC-ALL-ALL-MEAN